INSTRUCTION MANUAL

Serial Number ____________

TYPE 1A7 PLUG-IN UNIT

Tektronix, Inc.
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070-0379-00

1065


TYPE 1A7 PLUG-IN UNIT
HIGH-GAIN DIFFERENTIAL AMPLIFIER
VOLTS/CM
VARIABLE
mVOLTS
VOLTS
μVOLTS
CALIBRATED
POSITION
HIGH FREQ 3dB POINT
LOW FREQ 3dB POINT
INPUT OVERLOAD
GAIN
DC OFFSET
FINE
ON
OFF
+ INPUT
1MΩ 47pf
AC
GND
DC
COARSE
STEP ATTEN
DC BAL
FINE
− INPUT
SIGNAL OUTPUT
SERIAL
TEKTRONIX, INC.
PORTLAND, OREGON, U.S.A.

SECTION 1
CHARACTERISTICS

General Information

The Type 1A7 is a high-gain low-noise adjustable bandwidth dc-coupled differential amplifier. This unit is designed for use in all Tektronix 530-, 540-, 550-, and 580[1]-Series oscilloscopes and their rackmount equivalents. The Type 1A7 can also be used in conjunction with other oscilloscopes and devices through the use of a Tektronix Type 127, 132 or 133 plug-in power supply.

Minimum deflecion factor of the unit is 10 μV/cm. Maximum bandwidth is dc to 500 kHz at all deflection factors. When operating as a differential amplifier, the Type 1A7 has a stable common-mode rejection ratio (CMRR) of 50,000:1 or greater for dc to 100-kHz common-mode signals up to ±10 volts in amplitude.

Sensitivity

Nineteen calibrated deflection factors in a 1-2-5 sequence from 10 μV/cm to 10 V/cm.

The front-panel VARIABLE control has a 2.5:1 ratio or higher to provide continously variable uncalibrated deflection factor range from 10 μV/cm to at least 25 V/cm.

Gain Calibration Accuracy

A 10 μV/cm internal adjustment and a 10 mV/cm front-panel adjustment are provided to set the gain of the unit. When these adjustments are accurately set, the calibrated deflection factor accuracies at room ambient temperature (25° C ±5° C) are summarized in Table 1-1.

TABLE 1-1

VOLTS/CM Switch Position	Accuracy
10 μV/cm	Adjusted
20 μV/cm to 50 μV/cm	±2%
100 μV/cm to 5 mV/cm	±1.5%
10 mV/cm	Adjusted
20 μV/cm to 10 mV/cm	±2%

Gain Variation With Temperature

See Table 1-2. Accuracies apply at 0° C to 50° C ambient temperature after the gain adjustments are set properly at 25° C. Significant reduction in gain occurs only at temperatures below 15° C ambient, becoming most severe at 0° ambient.

TABLE 1-2

VOLTS/CM Switch Position	Accuracy
10 μV/cm	−8%, +2%
20 μV/cm to 100 μV/cm	−4%, +1%
200 μV/cm to 10 V/cm	±1%

[1]**580-Series oscilloscopes require a Type 81 Adapter.**

High Frequency Response

See Table 1-3 and Fig. 1-2.

TABLE 1-3

HIGH FREQ 3 dB POINT	
Switch Position	Accuracy
500 kHz	±20%
100 kHz to 100 Hz	±12%

Low Frequency Response

See Table 1-4 and Fig. 1-3.

TABLE 1-4

LOW FREQ 3 dB POINT	
Switch Position	Accuracy
DC	Not applicable
0.1 Hz to 100 Hz	±30%
1 kHz and 10 kHz	±12%

Transient Response

≤ ±2% aberration any bandwidth.

Maximum Allowable Input Voltage Rating

See Table 1-5.

TABLE 1-5

Maximum Input Voltage

VOLTS/CM Switch Position	Combined DC and Peak 60 Hz AC	
	(DC coupled)	(AC coupled)
10 μV/cm to 10 mV/cm	200 V	600 V
20 mV/cm to 10 V/cm	600 V	600 V

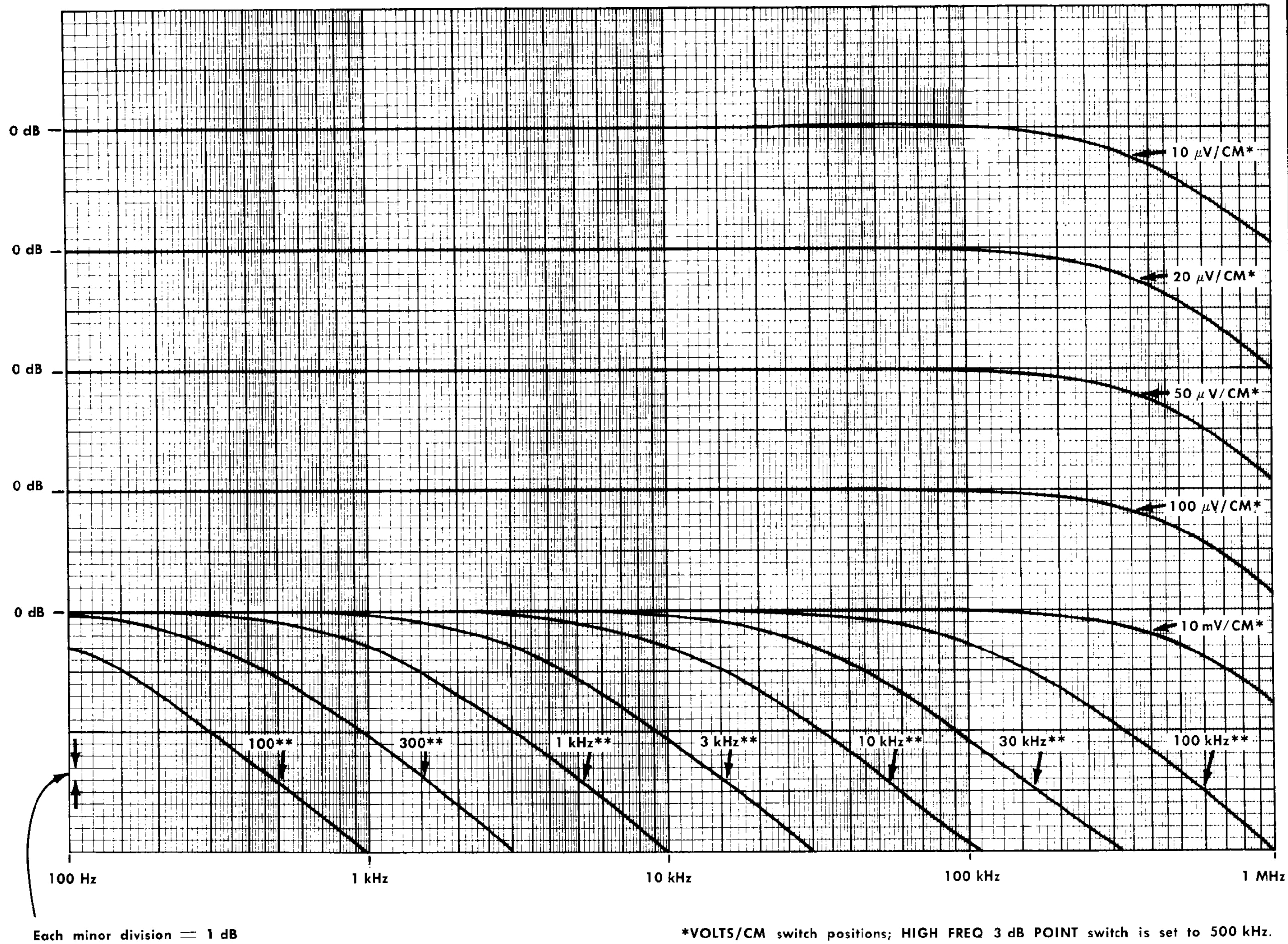
Maximum Common-Mode Input Voltage

See Table 1-6.

TABLE 1-6

VOLTS/CM Switch Position	Combined DC and Peak AC (DC coupled)	Peak AC (AC coupled)
10 μV/cm to 10 mV/cm	±10 V[2]	10 Vac, 600 Vdc
20 mV/cm to 0.1 V/cm	±100 V[2]	100 Vac, 600 Vdc
0.2 V/cm to 10 V/cm	600 V	600 Vac, 600 Vdc

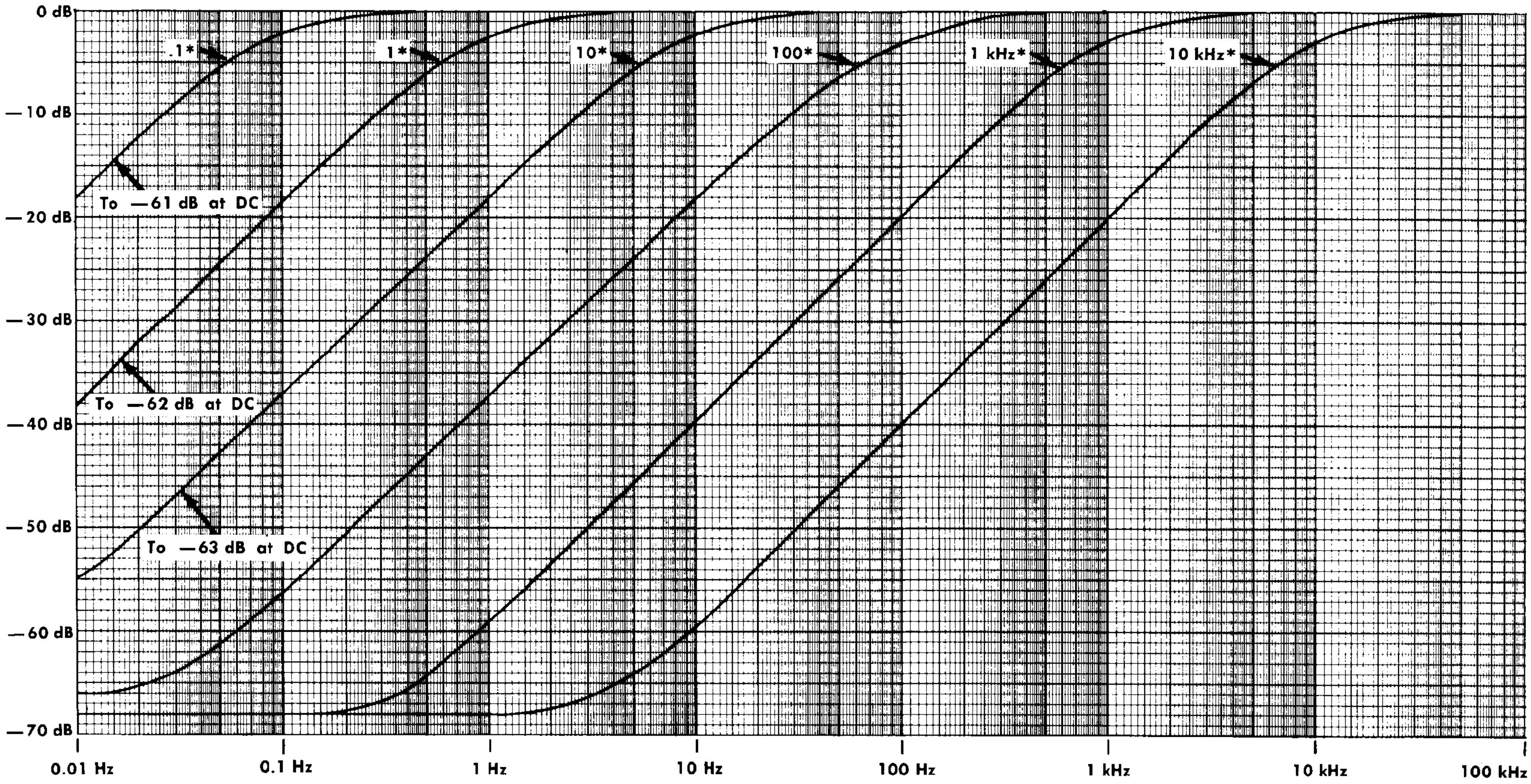
[2]**For ambient temperature below 30°C the common-mode input voltage rating from 10 μV/cm to 0.1 V/cm may be doubled with no appreciable effect on CMRR. The common-mode dynamic range is then ±20 V or 40 V peak to peak from 10 μV/cm to 10 mV/cm.**



*VOLTS/CM switch positions; HIGH FREQ 3 dB POINT switch is set to 500 kHz.

**HIGH FREQ 3 dB POINT switch positions; VOLTS/CM switch set to any position.

Fig. 1-2. Typical high frequency response of the Type 1A7 as a function of the HIGH FREQ 3 dB POINT and VOLTS/CM switch settings. The LOW FREQ 3 dB POINT switch is set to DC for all the curves.



*LOW FREQ 3 dB POINT switch positions.

Fig. 1-3. Typical low frequency response of the Type 1A7 as a function of the LOW FREQ 3 dB POINT switch setting (ac stabilization mode). The HIGH FREQ 3 dB POINT switch is set to 500 kHz for all curves.

Common-Mode Rejection Ratio (CMRR)

See Table 1-7 and Fig. 1-4. Characteristics apply at 25° C ±5° C.

TABLE 1-7

Peak-to-Peak Sine-Wave Common-Mode Signal	Input Coupling Switch	VOLTS/CM Switch Position	CMRR[3]
DC to 20 kHz, ≤20 V	DC	10 μV/cm to 10 mV/cm	Adjustable to ≥310,000:1
Dc to 100 kHz ≤20 V	DC	10 μV/cm to 10 mV/cm	≥50,000:1
Dc to 1 kHz, ≤200 V	DC	20 mV/cm to 10 V/cm	Adjustable to ≥5,000:1
1 kc to 100 kHz, ≤200 V	DC	20 mV/cm to 10 V/cm	Adjustable to ≥500:1
60 Hz, 20 V	AC	10 μV/cm to 10 mV/cm	≥2,000:1
60 Hz, 200 V	AC	20 mV/cm to 10 V/cm	

[3]Checked by applying a sine wave from an audio generator to both inputs on the Type 1A7. Set generator frequency and amplitude as specified in column 1 of the table. Set input coupling switches as directed in column 2 and check CMRR at each VOLTS/CM switch position. CMRR is the common-mode signal amplitude divided by the signal voltage displayed on the crt. Checked with DC OFFSET ON-OFF switch set to OFF.

Input Coupling Modes

Ac or dc, selected by front-panel switch.

A third position, GND, is provided to ground the amplifier input without grounding the signal source. Also, permits precharging the ac-coupling capacitor (see Section 2).

Input Coupling AC Low Frequency Response

—3 dB at 1.6 Hz.

With AC-GND-DC switch set to AC and the input driven from a source impedance which is negligible when compared with 1 megohm.

Input R and C

One megohm ±0.75% paralleled by 47 pF ±1.5%.

The 1-megohm input resistance can be eliminated to provide floating inputs when any of the ten most sensitive ranges (10 μV/cm to 10 mV/cm) are used for dc-coupled signals. Removable wire links are provided for this purpose on the attenuator etched wiring board. See Section 2.

Input Cross Neutralization

≤3% aberration.

Measured when driven grid is dc coupled and input coupling switch for undriven grid is set from GND to DC. Aberration on the display is expressed as a percentage of the original displayed amplitude.

Grid Current

Typically < 1 nanoamp (adjustable to zero) after a 20-minute warm up.

An internal calibration control diverts the grid current away from the input connector (except when the floating-input provision is used). The range of this control is adequate to divert up to 10 nanoamps.

Drift With Time: ≤ 20 picoamps/hr with ambient temperature and line voltage held constant, averaged over a 10-hour period.

Drift With Temperature: ≤ 50 picoamps/°C.

Dc Drift

With Time: ≤ 200 μV/hr with ambient temperature and line voltage held constant, averaged over a 10-hour period.

With Temperature: ≤ 150 μV/°C.

Dc Offset

See Table 1-8.

TABLE 1-8

VOLTS/CM Switch Position	Combined Coarse and Fine Range (+11%, —10%)	Input Attenuator Switched In
10 μV/cm to 10 mV/cm	±300 mV	X1
20 mVcm to .1 V/cm	±3 V	X10
0.2 V/cm to 1 V/cm	±30 V	X100
2 V/cm to 10 V/cm	±300 V	X1000

VARIABLE (VOLTS/CM) Dc Balance

3 mm maximum trace shift.

Shift in position of trace when VARIABLE control is rotated from detent to the fully counterclockwise position; with STEP ATTEN DC BAL FINE control properly adjusted and DC OFFSET ON-OFF switch set to OFF.

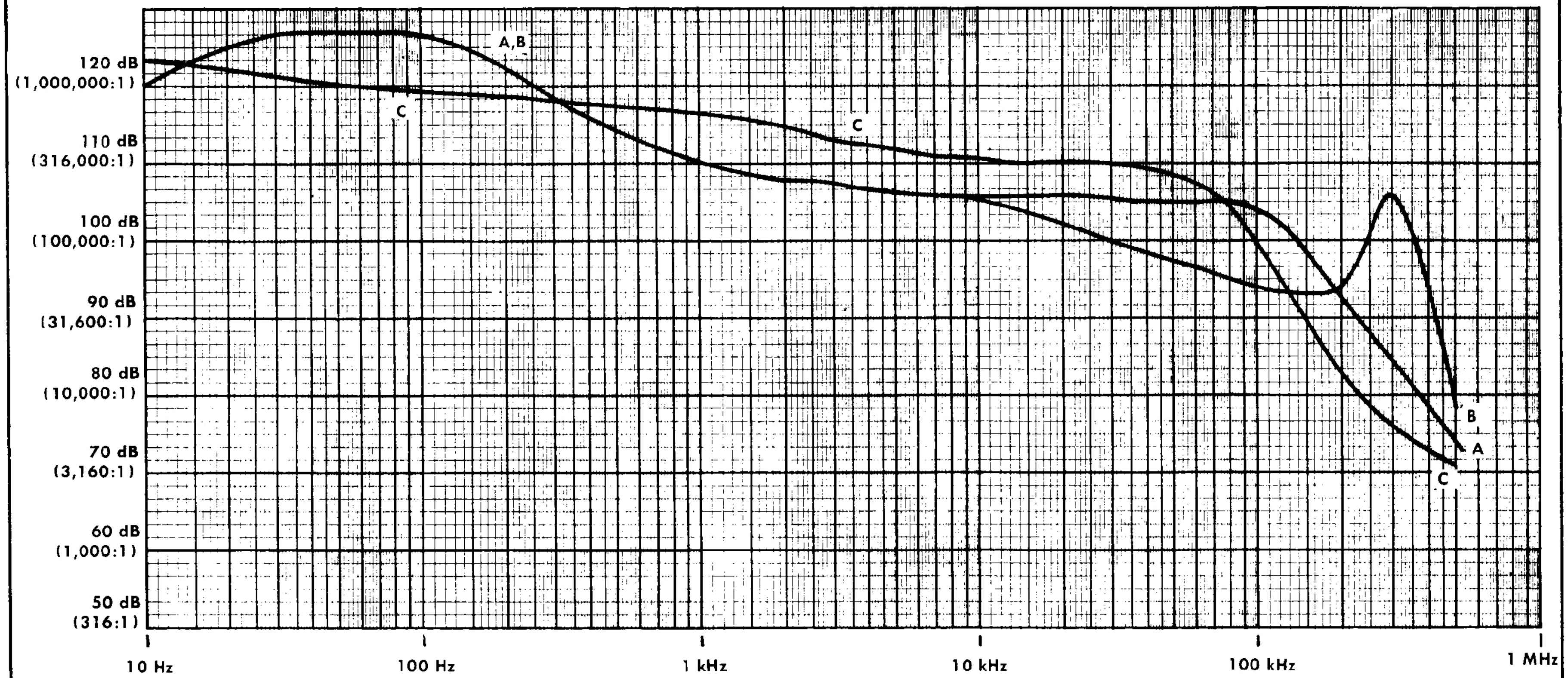
Equivalent Wide-Band Short-Circuit Input Noise Voltage

3.3 μV rms maximum above 5 Hz. See Fig. 1-5.

Equivalent Wideband Short Circuit Noise Resistance

≤ 800 ohms. See Fig. 1-5.

Equal to 10.2 mV rms at SIGNAL OUTPUT connector with VOLTS/CM switch set to 10 μV, LOW FREQ 3 dB POINT switch set to DC and HIGH FREQ 3 dB POINT switch set to 500 kHz.



A—Adjusted for maximum CMRR at 100 kHz.

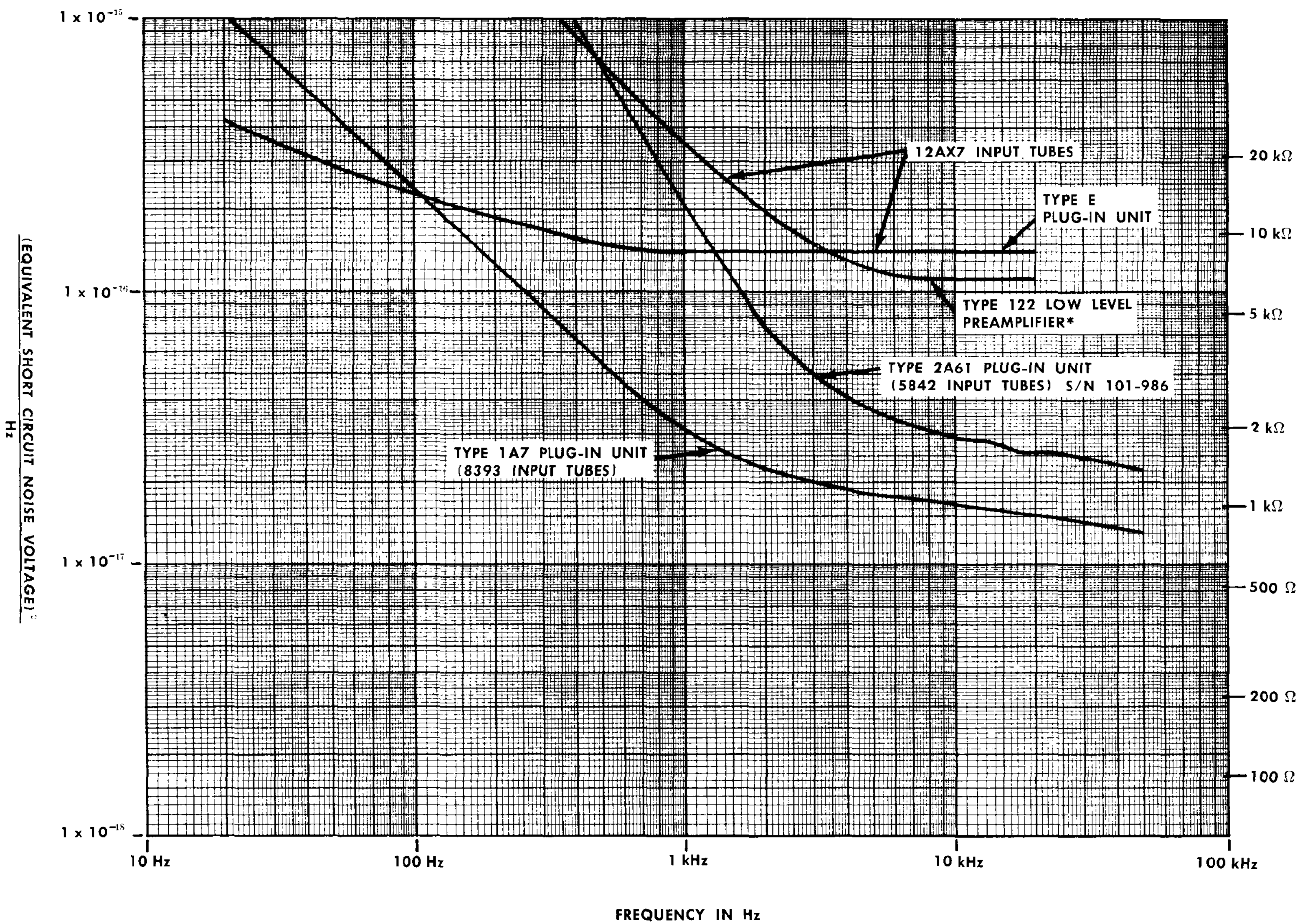
B—Adjusted for maximum CMRR at 300 kHz.

C—Adjusted for maximum CMRR from DC-20 kHz.

NOTE

±5 V (10 V p-p) common-mode signal is dc-coupled to the Type 1A7 amplifier at 100 μV/CM. The curves are essentially the same if 20 V p-p is applied.

Fig. 1-4. Typical CMRR vs frequency curves for the Type 1A7.



*According to Brophy, Review of Scientific Instruments, Nov. 1955, page 1076.

Fig. 1-5. Noise spectrum curves comparing the Type 1A7 with other Tektronix differential amplifiers.

NOTE

When an average reading rms calibrated voltmeter is used, a correction factor of 1.13 must be applied to the noise measurement. Multiply the reading by 1.13 to obtain a true rms value.

Signal Output

Dc Level: 0 volts at center screen. Internally adjustable to ground reference.

Amplitude: 34 mV, ±10% per display cm.

Frequency Response: Direct coupled, reproduces signal display on crt.

Output Impedance: 250 ohms ±20%.

Environmental

Storage: —40° C to +65° C, to 50,000 ft.

Operating Temperature: 0° to +50° C.

Operating Altitude: To 50,000 ft.

Mechanical

Construction: Aluminum-alloy chassis and front panel. Glass laminate etched-wiring boards.

Finish: Anodized front panel.

Accessories Included

Information on accessories for use with this instrument is included at the rear of the mechanical parts list.

SECTION 3
CIRCUIT DESCRIPTION

Introduction

The block diagram description is based primarily on the block diagram located on the fold-out page in Section 9 of this manual. To follow the detailed circuit description, refer to the illustrations provided in this section as well as the schematic diagrams in Section 9.

In general, when following the signal through the stages in the detailed description (particularly as indicated at the input and output of Figs. 3-3, 3-6 and 3-8), the Type 1A7 is set for single-ended operation and a positive-going (+ signal) is applied to the +INPUT connector. Since the amplifier and Emitter Follower stages in the Type 1A7 are the same (symmetrical) for both sides, the + input side is described in more detail.

BLOCK DIAGRAM DESCRIPTION

Signals applied to the +INPUT connector are applied via the AC-GND-DC switch SW101 to the +Input Attenuator. The attenuators for both sides are the conventional RC type with one exception. In the —Input Attenuator the resistive portion of the divider is adjustable so the —input side can be matched to the +input side to obtain optimum dc common-mode signal rejection.

From the +Input Attenuator the signal is applied to the Input Amplifier stage. Special constant-current bootstrap circuits in this stage allow handling of large common mode signals. In differential mode of operation, difference signals are amplified while common-mode signals are suppressed. A dc offset voltage can be inserted in this stage by means of the DC OFFSET ON-OFF switch, FINE and DC OFFSET controls.

Signals from the Input Amplifier are applied to an EF (Emitter Follower) stage. This stage provides a low-impedance drive for the Neon Bulb Driver and Gain-Switching Amplifier stages that follow. The Neon Bulb Driver stage is a non-linear amplifier that operates from the signal voltage in the EF stage. Excessive differential drive to the Type 1A7 input causes the Neon Bulb Driver to turn the INPUT OVERLOAD light on.

In the Gain-Switching Amplifier stage, the gain is controlled by switching different resistors between the collectors to shunt the collector load. In addition, the LOW FREQ 3 dB POINT switch is located in this stage to control the low-frequency 3-dB down point.

Signals from the Gain-Switching Amplifier stage are applied to the Output Amplifier for further amplification. Then the signals are applied via pins 1 and 3 of the interconnecting plug to the input of the oscilloscope vertical amplifier. Located in this stage are the HIGH FREQ 3 dB POINT, VARIABLE (VOLTS/CM) and positioning controls.

A single-ended signal is taken from pin 1 of the interconnecting plug and applied to the Signal Output CF stage. At the output of this stage, the signal is applied to the SIGNAL OUTPUT connector located on the front panel of the Type 1A7. Output signal is 34 mV for every cm of display on the oscilloscope screen.

There is about 3% variation between oscilloscopes in the regulated +75-volt supply. To minimize readjustment of the COARSE STEP ATTEN DC BAL control each time the Type 1A7 is transferred from one oscilloscope to another, the +75 volts is re-regulated. This is accomplished in the Regulated Heater Power Supply circuit of the Type 1A7. The added stability of this supply also decreases drift of the Type 1A7 Input Amplifier.

DETAILED CIRCUIT DESCRIPTION

Input Amplifier

The +INPUT coupling switch SW101 permits selection of ac or dc signal coupling, or grounding of the amplifier input without grounding the signal source. The GND position provides a ground reference for the unused grid for single-ended input applications. It also permits ac-coupling capacitor C102 to be charged or discharged before the signal is applied to the parallel-connected input grids. To accomplish this, the output end of C102 is grounded and R101 is placed between the +INPUT connector and the input side of C102 (see Fig. 3-1) to limit the charging current. Capacitor C101 is used with R101 so the GND position of the input coupling switch presents the same load to the circuit under test as the AC position.

The VOLTS/CM switch has decade attenuators that range from 1× to 1000×. Several desirable characteristics are provided by these attenuators:

1. The input time constant is established at 47 μs (1 MΩ × 47 pF) and equalized at all settings of the VOLTS/CM switch for both input connectors. In the +input 1× attenuator position, this is accomplished by adjusting C111 (see Fig. 3-2). Adjustable capacitors C105B, C106B, and C107B (refer to Attenuators diagram) serve the same purpose for the other +input attenuator positions.

2. The resistive (dc or low-frequency) attenuation ratios of the +input and —input attenuators are equalized by adjusting R205E, R206E, and R207E.

3. Attenuator (ac) compensation and equalization of the +input and —input attenuator compensations are obtained by adjusting C105C, C205C, C106C, C206C, C107C and C207C.

Total grid current for tubes V124 and V134 is normally about 3 nanoamperes and this produces a voltage drop of about 3 mV across R112. Under no-signal conditions the +GRID CURRENT control R115 is set to restore the grid voltage to zero in the presence of the R112 voltage drop. As a result, the position of the trace coincides with zero reference on the screen.

For special applications, the strap or wire link connected from the grids of V124-V134 (see Fig. 3-2) to R112 can be removed to provide a substantially higher input resistance

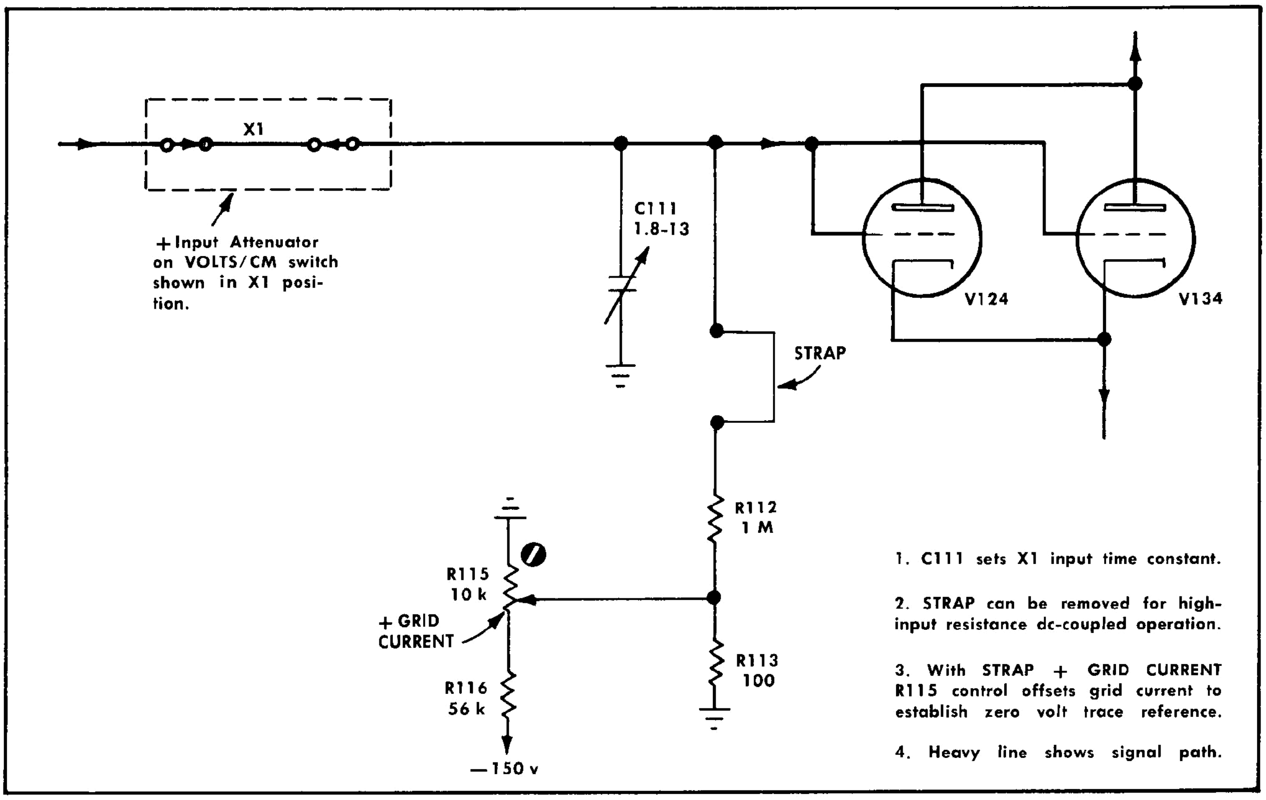


Fig. 3-2. Simplified grid circuit diagram of the +input side in the Input Amplifier stage.

control balances the gain of the stage so common-mode rejection requirements can be met. Adjustment of this control does not cause any dc current to flow through the wiper arm of R175 because the arm is connected to a potential which is equal to the voltage on the plates of V124 and V134.

To dc balance the stage with zero volts on the grids of the tubes, two controls are involved: STEP ATTEN DC BAL COARSE and STEP ATTEN DC BAL FINE. The STEP ATTEN DC BAL COARSE control R500, as shown on the Regulated Heater Power Supply diagram, provides a differential adjustment of V124-V134 and V224-V234 heater voltages. A change in heater voltage effectively controls the cathode temperature and, hence, the grid bias of the tube. The COARSE control R500 is set so the plate currents for both sides are equal.

The STEP ATTEN DC BAL FINE control R170 (see Fig. 3-3) has a similar purpose and effect to that of the COARSE control R500, but with a much narrower range of adjustment, and without thermal time lag. Current is added to the emitter of Q144 and diverted from the Q244 emitter, or vice versa, so the collector voltages of these transistors are equalized. Thus, this control affects the dc current through both sides but not the common-mode rejection.

Variable capacitors C121 and C221 provide a small amount of positive feedback to neutralize the effects of tube inter-electrode capacitances.

C143 is a dual-section trimmer that has a common rotor for differentially adjusting the capacitances in the plate circuits. This adjustment is effective only in the presence of common-mode signals. Then, it is adjusted to equalize the two sides for maximum common-mode rejection at high frequencies.

The dc offset circuit (see Fig. 3-5) is essentially a differential amplifier with a long tail. Transistors Q154 and Q254 form the differential amplifier and Q158 is the long tail. With the DC OFFSET ON-OFF switch SW155 in the ON position, Q254 is tied to a voltage divider made up of R161, R162, R163 and R164; the base of Q154 is tied to variable voltage dividers which consist of the DC OFFSET R168 and the FINE R165 controls.

Variable controls R165 and R168 are able to swing the base of Q154 about 10 volts. This swing is converted into a differential current which adds to one side while subtracting an equal amount from the other side. Total current is held constant by Q158. The unbalanced currents in the two sides cause the trace to move up or down, depending on the direction of control rotation. Any noise generated by rotating the controls is converted into a common-mode signal by C155. The high CMRR of the stage rejects the noise.

At sensitivities from 10 mV/cm to 10 μV/cm, actual offset is +300 mV in one direction and —300 mV in the other direction as observed on the screen. Actual offset range within the amplifier remains the same for all sensitivities. However, the offset range referred to the input connectors

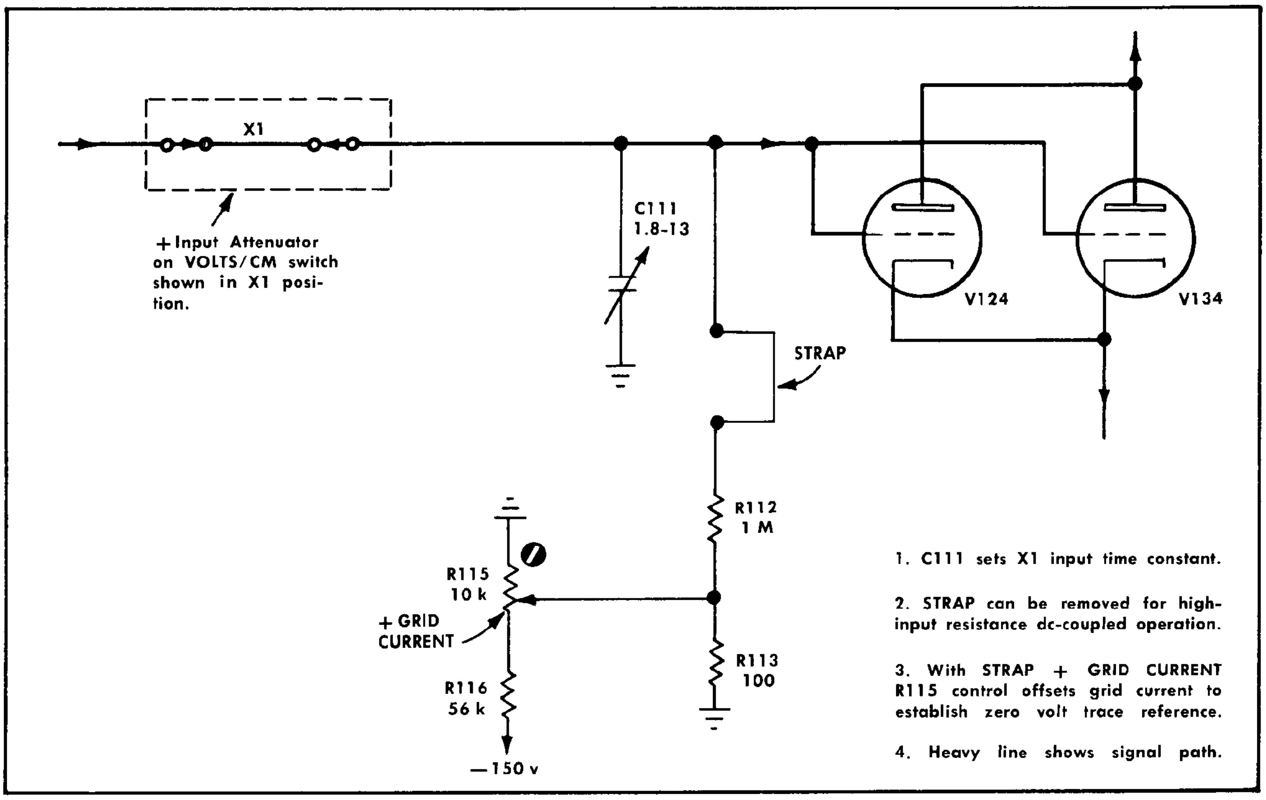


Fig. 3-2. Simplified grid circuit diagram of the +input side in the Input Amplifier stage.

control balances the gain of the stage so common-mode rejection requirements can be met. Adjustment of this control does not cause any dc current to flow through the wiper arm of R175 because the arm is connected to a potential which is equal to the voltage on the plates of V124 and V134.

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Variable controls R165 and R168 are able to swing the base of Q154 about 10 volts. This swing is converted into a differential current which adds to one side while subtracting an equal amount from the other side. Total current is held constant by Q158. The unbalanced currents in the two sides cause the trace to move up or down, depending on the direction of control rotation. Any noise generated by rotating the controls is converted into a common-mode signal by C155. The high CMRR of the stage rejects the noise.

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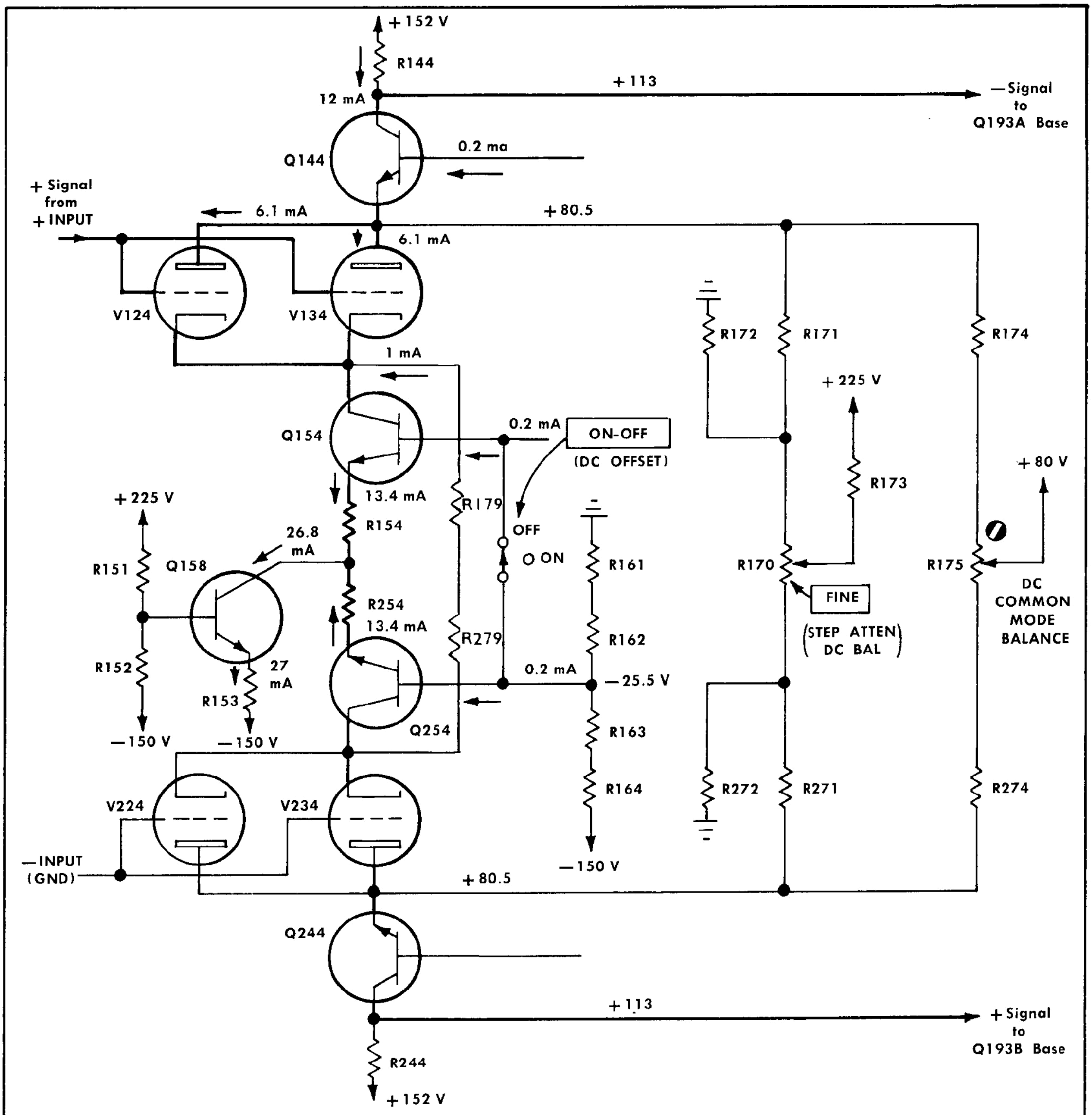


1. For the circuit description the amplifier is set for single-ended + signal-input operation. Heavy lines represent signal paths. Small arrows show direction of conventional current.

2. V124 and V134 are parallel-connected to divide the currents. Reduces noise and increases dynamic operating range.

3. V124, V134 and Q144 operate as a cascode amplifier.

4. Q154 is a long-tail constant-current source for the + INPUT side.

5. Q158 is a constant-current source for both sides.

6. Voltage gain is about 16 between grid of V124 and collector of Q144.

7. DC OFFSET ON-OFF switch is shown in the OFF position to simplify the circuit. Also, upper side of Input Amplifier circuit is shown in more detail than the lower side.

Fig. 3-3. Simplified (partial diagram) of Input Amplifier showing signal path, approximate currents and electrical location of some of the controls.

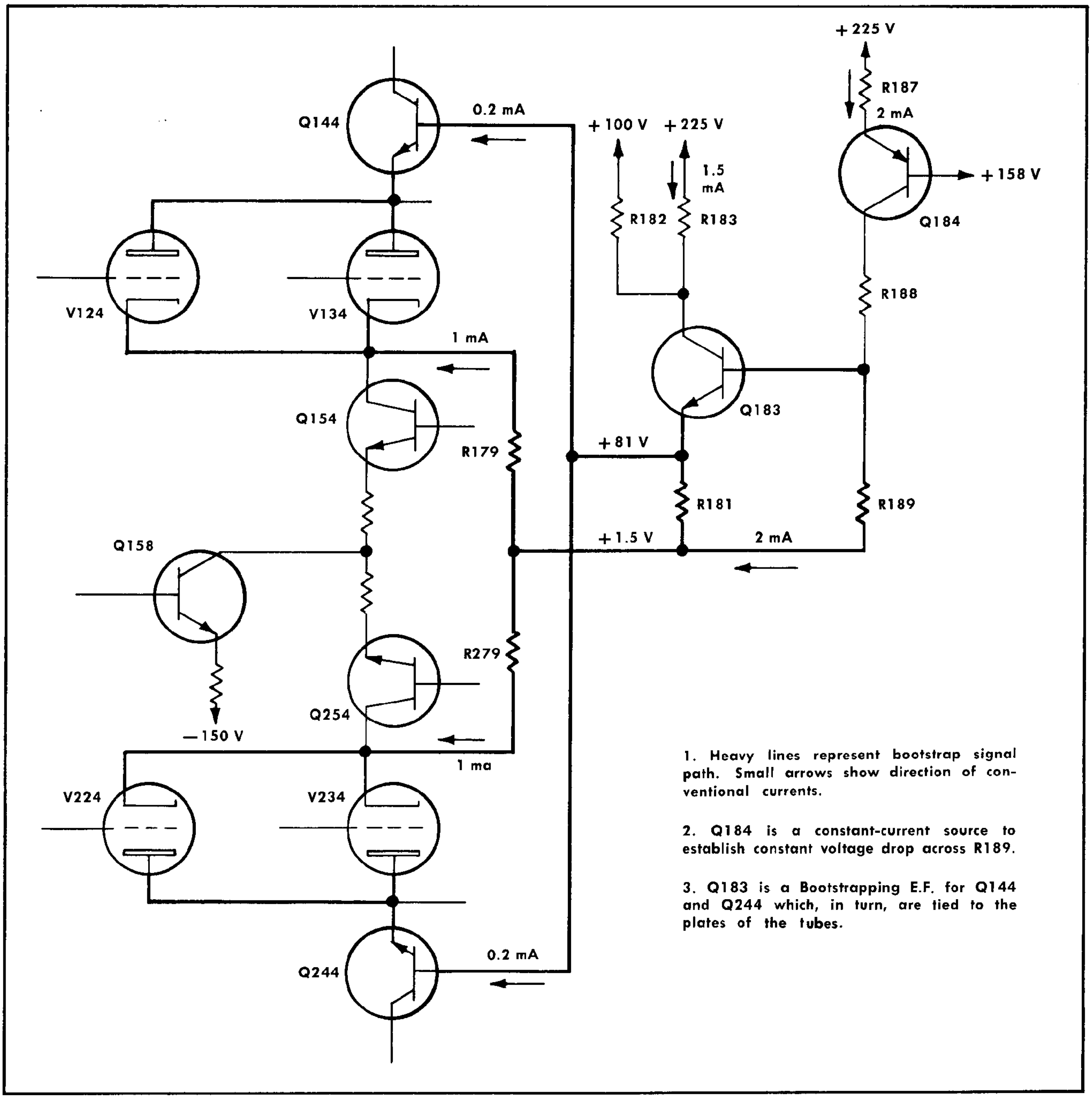


Fig. 3-4. Simplified (partial) diagram of Input Amplifier showing bootstrapping circuit and approximate center-screen currents.

is effectively multiplied by the decade attenuators as they are switched into the circuit by the VOLTS/CM switch.

Emitter Follower

Signals from the Input Amplifier are applied to the EF Q193A-Q193B stage (see Fig. 3-6). This stage provides a low-impedance drive for the following stages. When an unbalanced signal is applied to the Type 1A7, a slight dc shift will occur due to a short-term time constant in the amplifier. To compensate for this time-constant, a network is connected between the bases of Q193A and Q193B. This network consists of C190, R290 and a DC SHIFT control R190. The control is adjusted so the trace quickly returns to zero reference when the unbalanced signal is disconnected.

Neon Bulb Driver

The Neon Bulb Driver stage consists of Q304 and Q404 with associated circuitry (see Fig. 3-7). This stage is a simple non-linear amplifier for input signals or difference voltages that are applied between the bases of the transistors. To

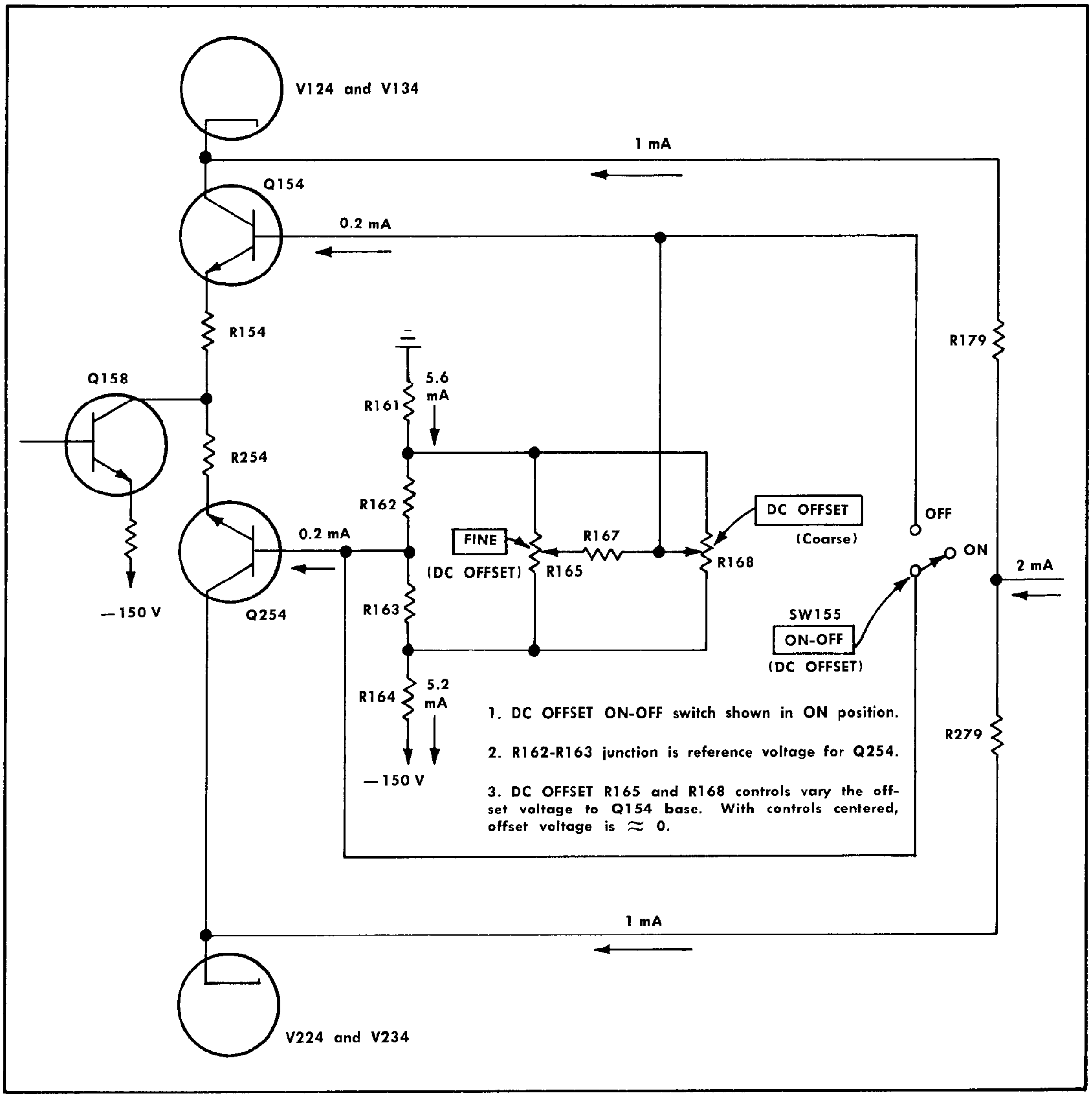


Fig. 3-5. Simplified dc offset circuit. Small arrows show direction of conventional current.

function as an amplifier, the difference voltage must be less than the Zener diode voltage which is about 6.2 volts. Under these conditions, Q304 and Q404 are conducting. R305 and R405 are the emitter resistors for their respective transistors; R304 and R404 are the collector load resistors. Gain of the stage is about 0.5.

If the difference voltage between the bases is greater that the Zener voltage, then the stage functions as a switch to turn on B309. One transistor or the other is driven into saturation while the other is driven into cutoff, depending upon the direction of applied voltage. The difference voltage between the collectors turns on B309.

For example, if the base of Q304 is driven about 7 volts negative with respect to Q404 base, Q304 cuts off. Zener diode D305 turns on and causes D405 to conduct in a forward direction as Q404 goes into saturation. Thus, the Zeners essentially connect R305 in parallel with R405 so both resistors carry the current for Q404. With Q304 cut off, its collector rises from +169 to about +221 volts; Q404 collector drops from +169 to about +120 volts. The difference voltage between the collectors is about 101 volts and B309 turns on.

If the base of Q304 is driven 7 volts positive with respect to Q404 base, the opposite action occurs. D304 goes into

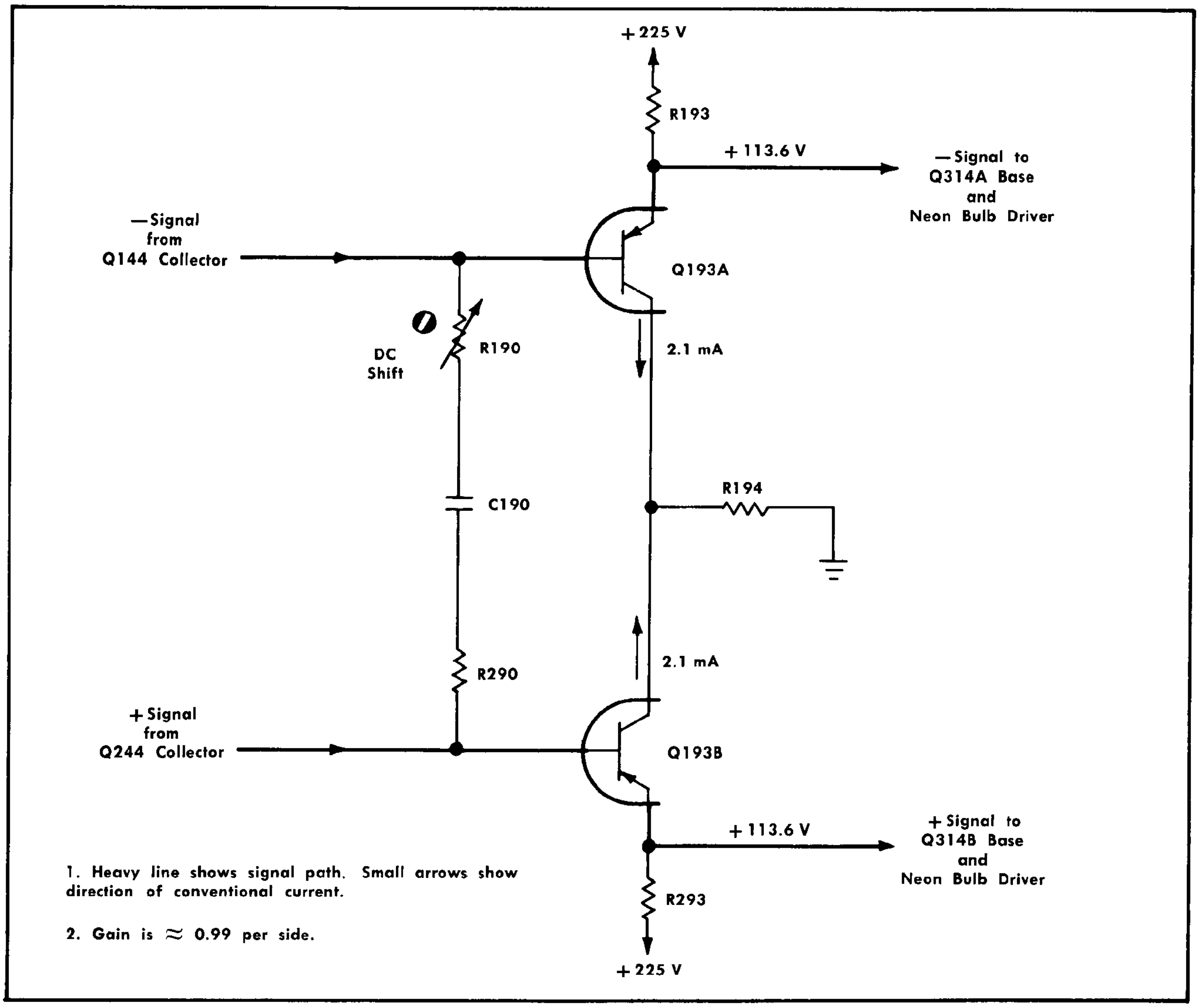


Fig. 3-6. Simplified E. F. stage showing approximate center-screen currents and signal paths.

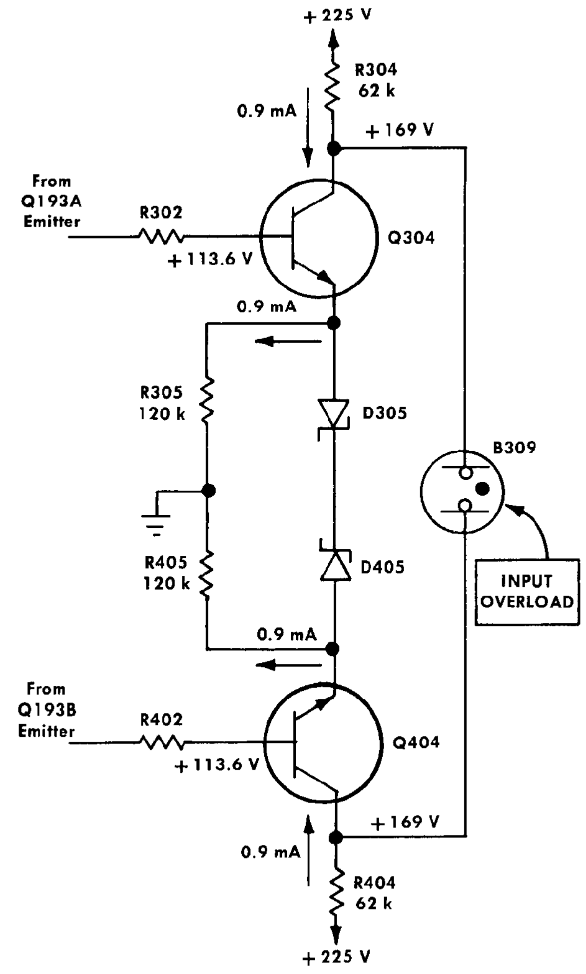
saturation as D405 turns on and causes D305 to conduct in a forward direction. The Zeners connect R405 in parallel with R305 to complete the emitter circuit for Q304. The difference voltage between the collectors is sufficient to turn on B309.

Gain-Switching Amplifier

The Gain-Switching Amplifier stage is composed of Q314A, Q314B, Q324 and Q424 with associated circuitry. Dual transistor Q314A and Q314B is the amplifier for each side. Q324 and Q424 are the constant current transistors for Q314A and Q314B, respectively. Voltage gain for the stage is about 31 at the minimum deflection factor of 10 μV/cm.

There are two gain controls in the stage: GAIN R308 and 10 μV GAIN R345. First, the GAIN control R308 is adjusted so the deflection factor is 10 mV/cm when the VOLTS/CM switch is set to 10 mVOLTS and the VARIABLE control is set to CALIBRATED. Then, the VOLTS/CM switch is set to 10 μVOLTS and the 10 μV GAIN control R345 is adjusted for a deflection factor of 10 μV/cm. Once these controls are properly adjusted, the deflection factors between 10 μV/cm and 10 mV/cm will be correct.

At 10 μV/cm the collector-to-collector load resistance is adjusted to exactly 50 kΩ by R345. To change the deflection factor of the unit in a 1-2-5 sequence from 10 μV/cm to 10 mV/cm, precision resistors are connected in shunt with the load resistance by means of the VOLTS/CM switch. For example, when the VOLTS/CM switch is set to 20 μVOLTS, R335A, a 50-kΩ resistor (see Attenuators schematic), is connected in shunt with the 50-kΩ collector load. The two 50-kΩ resistances connected in parallel cause the gain of the stage to drop by ½ or 20 μV/cm. This same pattern is used to change the gain for the remaining deflection factors to 10 mV/cm. For deflection factors from 20 mV/cm to 10 V/cm, shunt resistors R335G, R335H and R335J are recycled as the decade input attenuators are switched into the circuit.



1. Center-screen conditions: Q304 and Q404 are conducting; D305, D405 and B309 are off.

2. If Q304 base is driven 7 volts negative with respect to Q404 base, Q304 cuts off. D305 turns on and D405 forward conducts as Q404 saturates. D309 turns on.

3. If Q304 base is driven 7 volts positive with respect to Q404 base, Q304 saturates as D405 turns on and D305 forward conducts. Q404 cuts off and B309 turns on.

Fig. 3-7. Neon Bulb Driver stage showing approximate center-screen-current conditions.

Emitter degeneration is used to control the low-frequency response of the unit. The amount of degeneration is determined by capacitors C330A through C330F (see Bandpass Switches diagram) when used in conjunction with an emitter impedance of 1.59 kΩ. For example, if the LOW FREQ 3 dB POINT switch is set to 1, a 100 μF capacitor (C330B) is connected into the Q314A-Q314B emitter circuit (see Fig. 3-9a). Substituting these values in the formula, $f = \frac{1}{2\pi RC}$ the 3-dB down point is 1.0 Hz. Accuracy is mostly dependent on the tolerance of the capacitors.

When the LOW FREQ 3 dB POINT switch is set to DC, C330B is used once again in conjunction with emitter resistors R331 and R431 (see Fig. 3-9b) to provide dc shift compensation for a long-term time constant in the amplifier.

In the 10 μVOLTS to 100 μVOLTS position, the 5R section of the VOLTS/CM switch (see Attenuators diagram) is used to insert frequency-compensating networks into the Q314A-Q314B emitter circuit. The networks aid in maintaining the frequency response to 500 kHz at these sensitivities. Another frequency-compensating network, C327 and R327 (see Vertical Output Amplifier diagram), ensures clean transient response to 500 kHz, particularly in the least sensitive positions.

Capacitors C311 and C411 cross-neutralize the stage to prevent changes in frequency response as the VOLTS/CM switch is set to its various positions.

To make up for slight differences in beta and resistor tolerances between the two sides, an AC ATTEN BAL control (R235) is provided. This control is adjusted for minimum trace shift as the VOLTS/CM switch is set from the 10 mVOLTS to 10 μVOLTS position. For proper adjustment of R325 the LOW FREQ 3 dB POINT switch should be in the 10 kHz position, and the HIGH FREQ 3 dB POINT switch should be in the 100 Hz position.

Output Amplifier

The Output Amplifier is a conventional push-pull amplifier which consists of Q354A, Q354B and Q364 with associated circuitry. Q354A and Q354B comprise a dual transistor which is used in the amplifier portion of the circuit; Q364 is a constant current transistor. Gain of the stage is nominally 12 when the VARIABLE control R360 is set to CALIBRATED. If the preceding stages are properly dc balanced, the voltage between the emitters of Q354A and Q354B is zero and there is no trace shift as the VARIABLE control is rotated. C351 and C451 cross-neutralize the stage so the frequency response remains constant when rotating the VARIABLE control.

In the CALIBRATED position of the VARIABLE control, SW360 is closed to short out R360 so the gain of the stage is maximum. As the control is rotated a few degrees counterclockwise, SW360 is opened so the control can be used to vary the amount of emitter degeneration, and thus control the gain of the stage.

Transistor Q364 aids in removing any common-mode signals that might appear internally in the amplifier. High-frequency response of the Type 1A7 is controlled by shunting different capacitors across the output of the stage. Taking into consideration R373, R378, R473, R478 and the collector impedance of Q354, collector load resistors R354 and R454 cause the output resistance to be about 15.9 kΩ. Using the same formula as described for the LOW FREQ 3 dB POINT switch positions, the 15.9 kΩ output resistance in conjunction with the capacitor switched into the circuit by the HIGH FREQ 3 dB POINT switch SW330B determines the high-frequency response of the unit. In the 500 kHz position of the HIGH FREQ 3 dB POINT switch, stray capacitance is about 25 pF and the high-frequency 3-dB down point is 500 kHz. When the switch is set to 100 kHz, the stray capacitance is essentially connected in parallel with C370G (see Bandpass

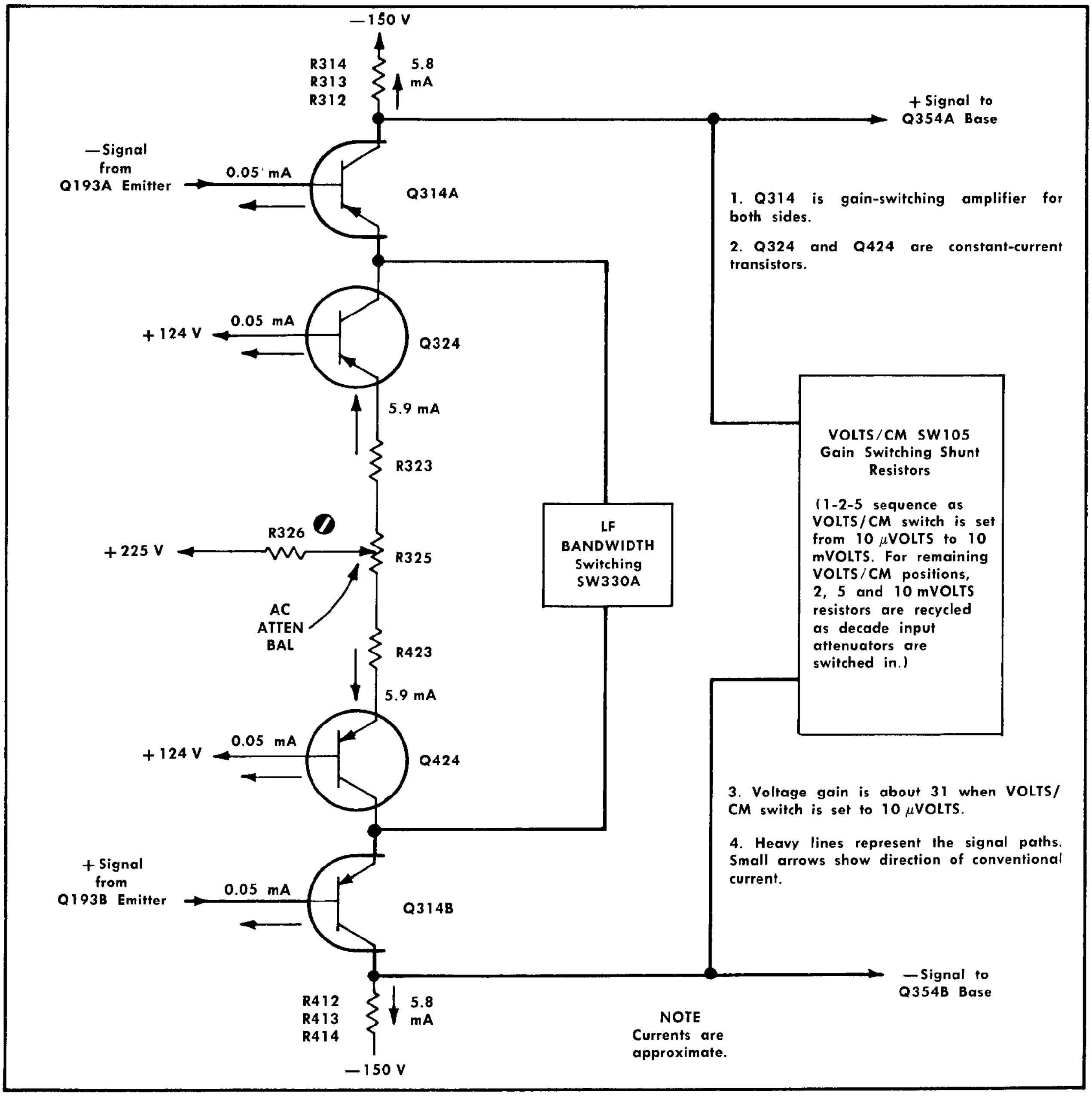


Fig. 3-8. Gain-Switching Amplifier stage.

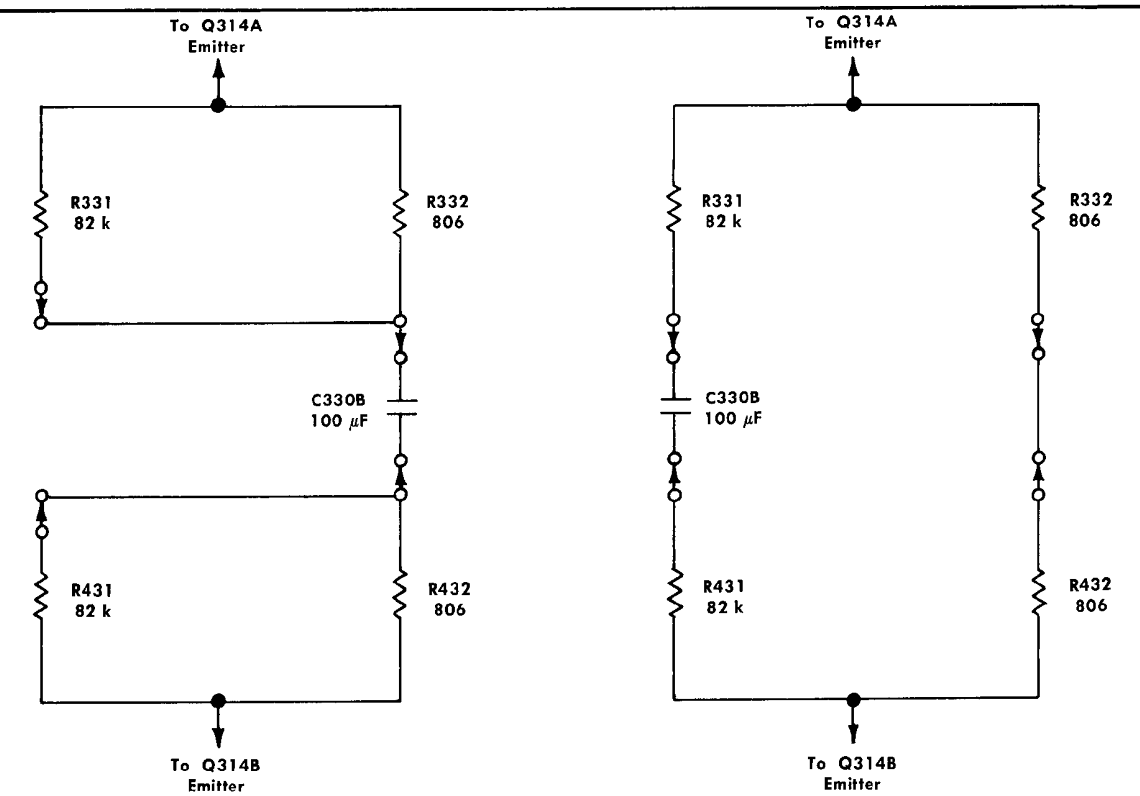
Switches diagram). Thus the total capacitance is about 100 pF, so the upper-end bandpass is 100 kHz.

Normal vertical positioning of the trace is accomplished by rotating the POSITION control R375. The positioning range of this control is about ±9 cm. As the control is rotated in either direction from its midrange position, the control shunts more current through one load resistor (R354 or R454) or the other. To center the trace when the POSITION control is set to midrange and the amplifier is properly dc balanced, VERT POS RANGE control R380 is provided.

Output signal polarity at pin 1 of the interconnecting plug is the same polarity as the polarity of the signal applied to the +INPUT connector. At pin 3 the signal polarity is the opposite to that of pin 1 and the +INPUT connector.

Signal Output Cathode Follower

At pin 1 of the interconnecting plug a single-ended signal is taken off and applied to a divider consisting of R492, R491 and R490. This divider lowers V493 grid voltage so the output voltage at the SIGNAL OUTPUT connector J495



(a) LOW FREQ 3 dB POINT switch set to 1; C330B degenerates frequencies below 1 Hz.

(b) LOW FREQ 3 dB POINT switch set to DC; C330B is used in a long-term time constant network to correct for dc shift.

Fig. 3-9. Simplified circuit showing how C330B is used twice.

is near zero. The SIGNAL OUTPUT DC LEVEL control R490 is adjusted so the voltage at the connector is zero when the trace is positioned to graticule center.

Variable capacitor C493 is used to frequency-compensate the divider so the capacitive reactance ratio is equal to the resistance ratio. Signal polarity at the SIGNAL OUTPUT connector is the same as that at pin 1 of the interconnecting plug; i.e., positive for a positive signal applied to the +INPUT connector.

Regulated Heater Power Supply

The +75-volt regulated supply from the oscilloscope is re-regulated by Q504A, Q504B, and Q517 with associated circuitry. Q504A and Q504B form a difference amplifier. These transistors are enclosed in one case so their environmental conditions will be similar, thus reducing drift. Q517 is a voltage regulator connected in shunt with R519 and in series with the heaters (see Fig. 3-10).

Zener diode D507 is used as a reference and is driven from the regulated +25-volt source located at the junction of R512 and R501. A relatively stable current of 7.5 mA flows through R507 to operate the Zener. D507 provides a constant dc voltage of about +9 volts at the base of Q504A with respect to ground. The base voltage for Q504B is set by divider resistors R501 and R502.

Re-regulation of the +75 volts (nominal), in the presence of a 3% difference voltage between oscilloscopes, is accomplished by varying the impedance of Q517 in a direction to compensate for the change. For example, assume the supply is lower than its nominal value of +75 volts. This will lower the base of Q504B and alter the current distribution through the difference amplifier. That is, current through Q504B will decrease a certain amount; current through Q504A will increase so the total current through R503 remains constant.

A decrease in current through Q504B causes its collector voltage to increase and raise the base of Q517. Current through Q517 increases and its impedance is lower. The decrease in Q517 impedance causes a decrease in voltage drop across Q517 and raises its emitter to the proper value.

As shown in Fig. 3-10, R519 is used to handle most of the current in the circuit while Q517 and R515 carry the

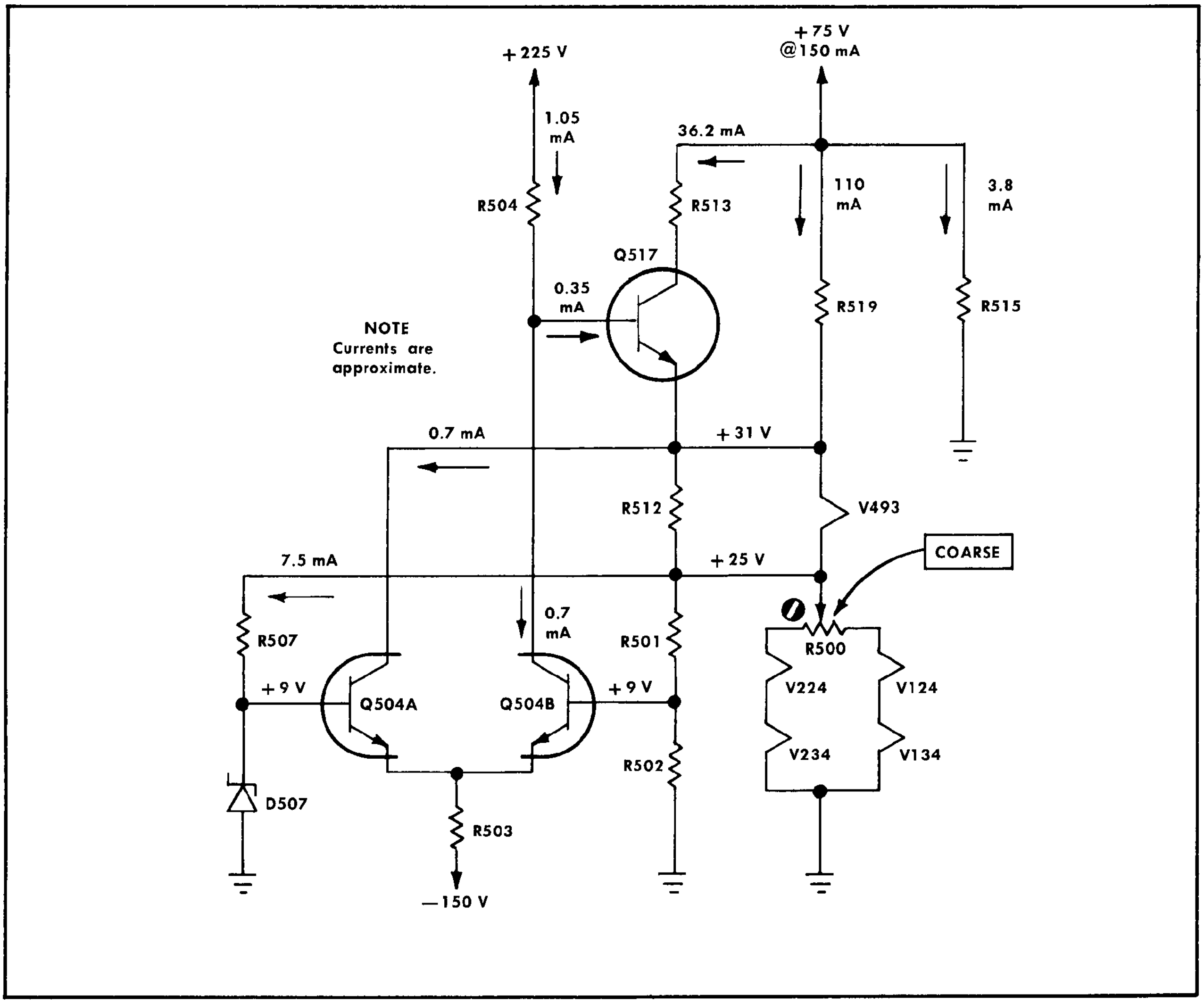


Fig. 3-10. Simplified Regulated Heater Power Supply circuit. Currents are approximate.

remainder. R512 is used as a shunt resistor to bypass the extra current not used by the heater of V493, but needed for the rest of the load circuit. As explained earlier, the COARSE control R500 is used to differentially adjust the heaters so the grid biases for the tubes in the two sides of the Input Amplifier are equal.

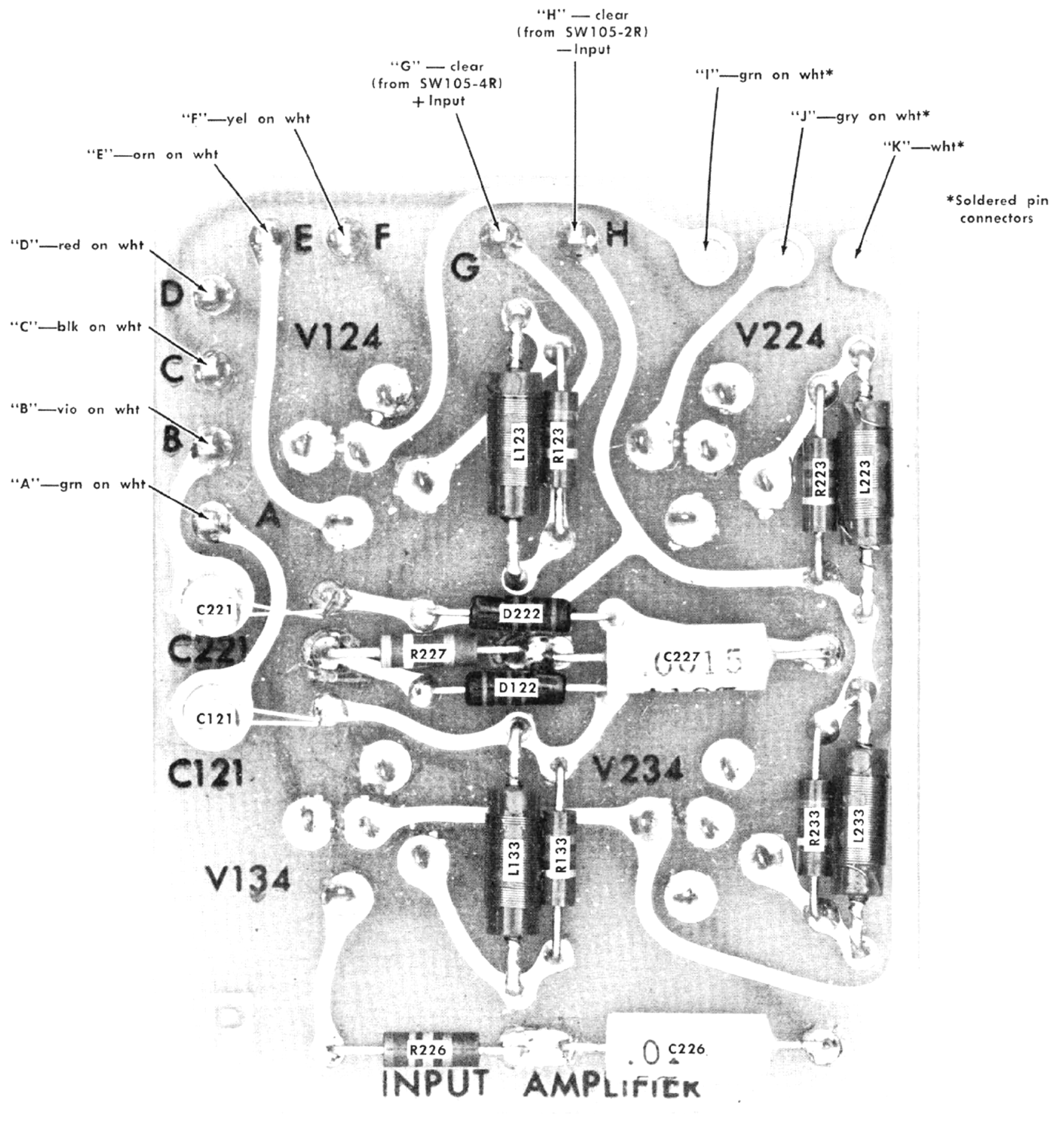


Fig. 4-4. Top view of Input Amplifier etched-wiring board.

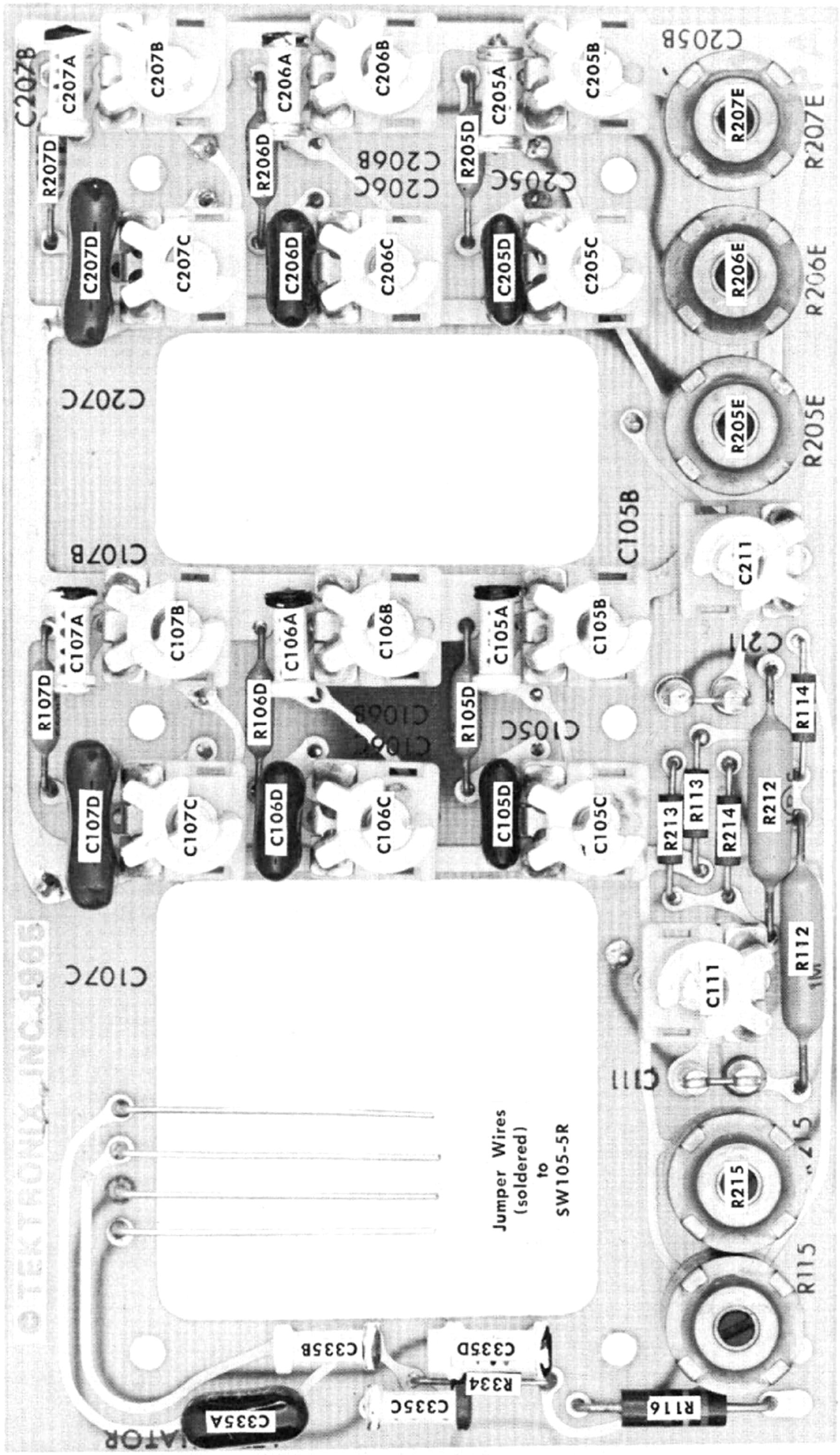
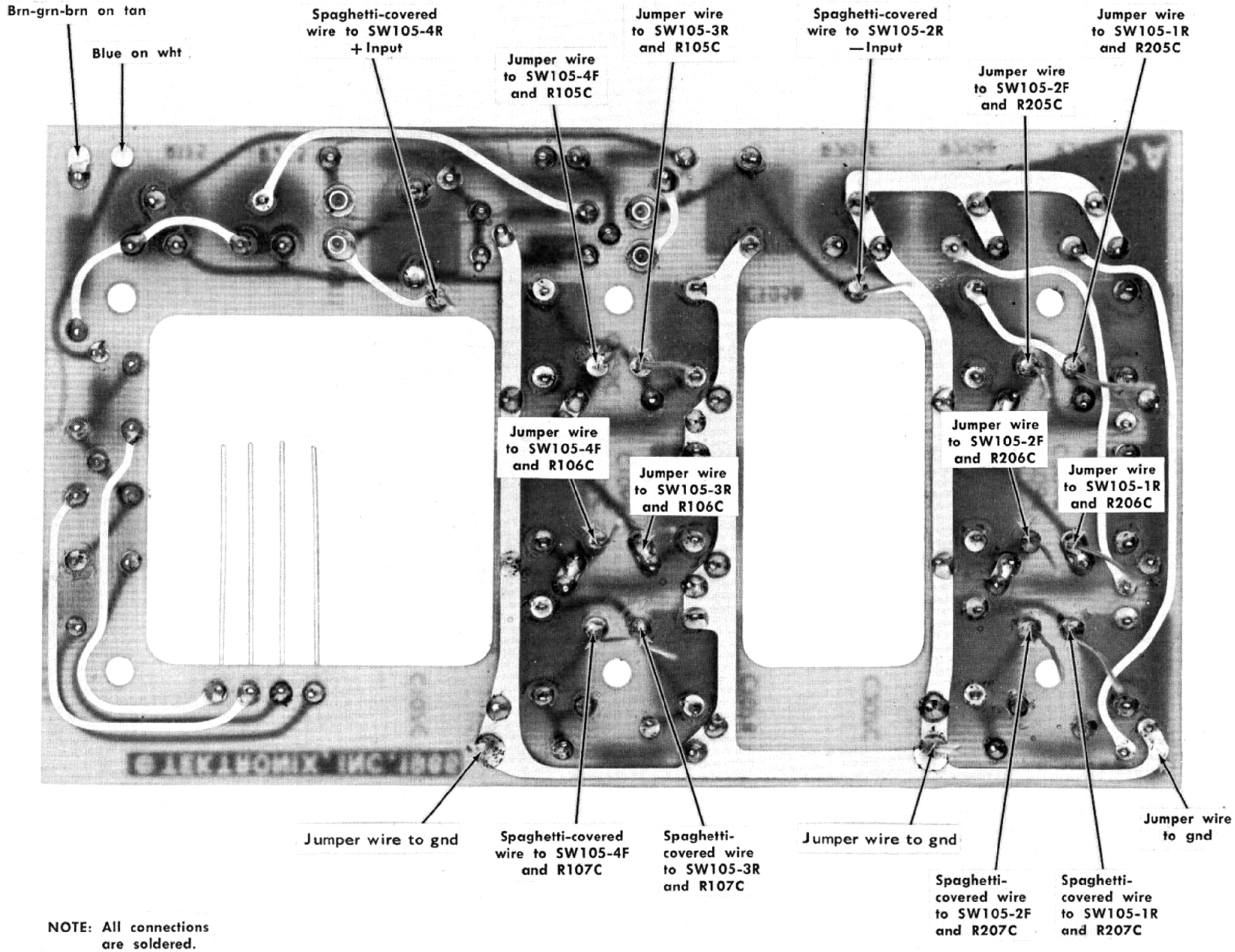


Fig. 4-5. Top view of Attenuator etched-wiring board.



NOTE: All connections are soldered.

Fig. 4-6. Bottom view of Attenuator etched-wiring board identifying the interconnecting wiring.

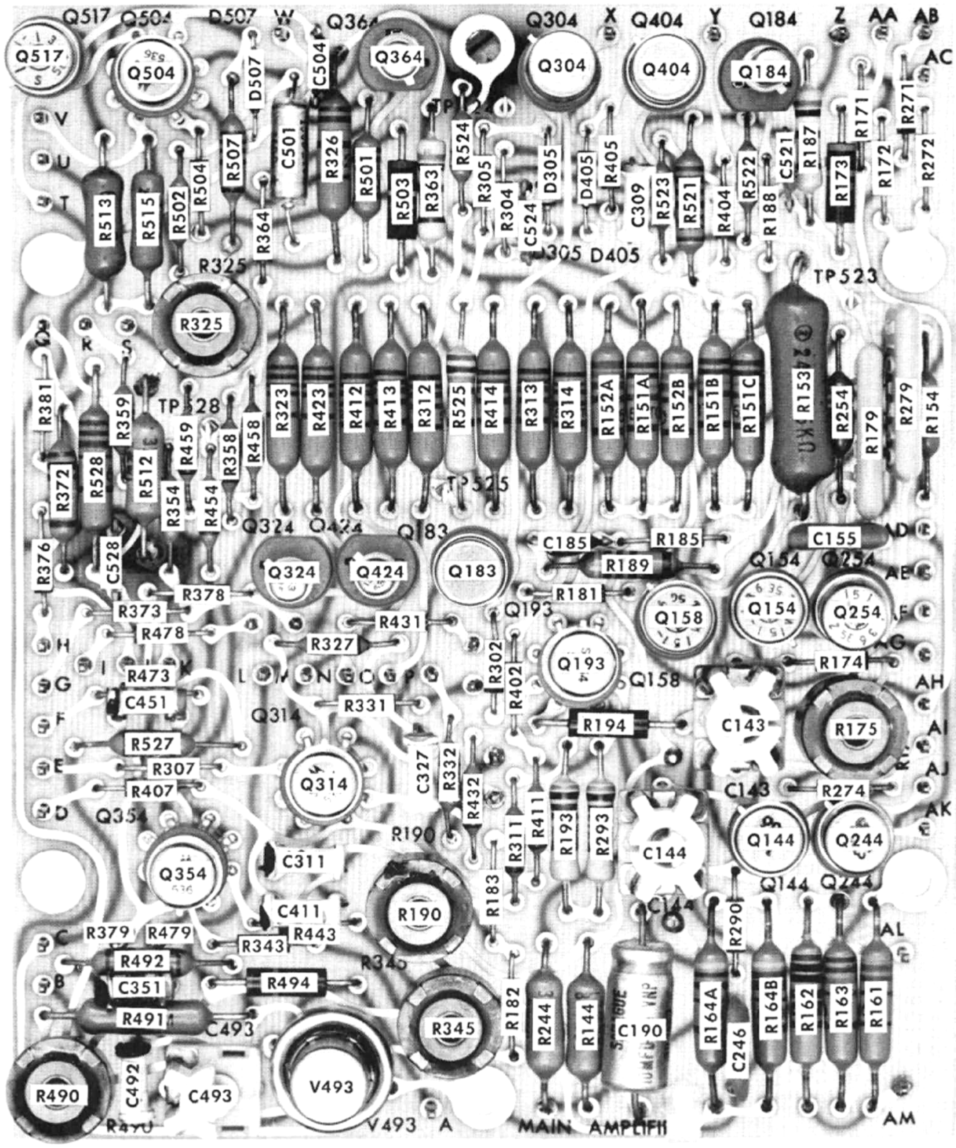


Fig. 4-7. Top view of Main Amplifier etched-wiring board showing component circuit numbers.

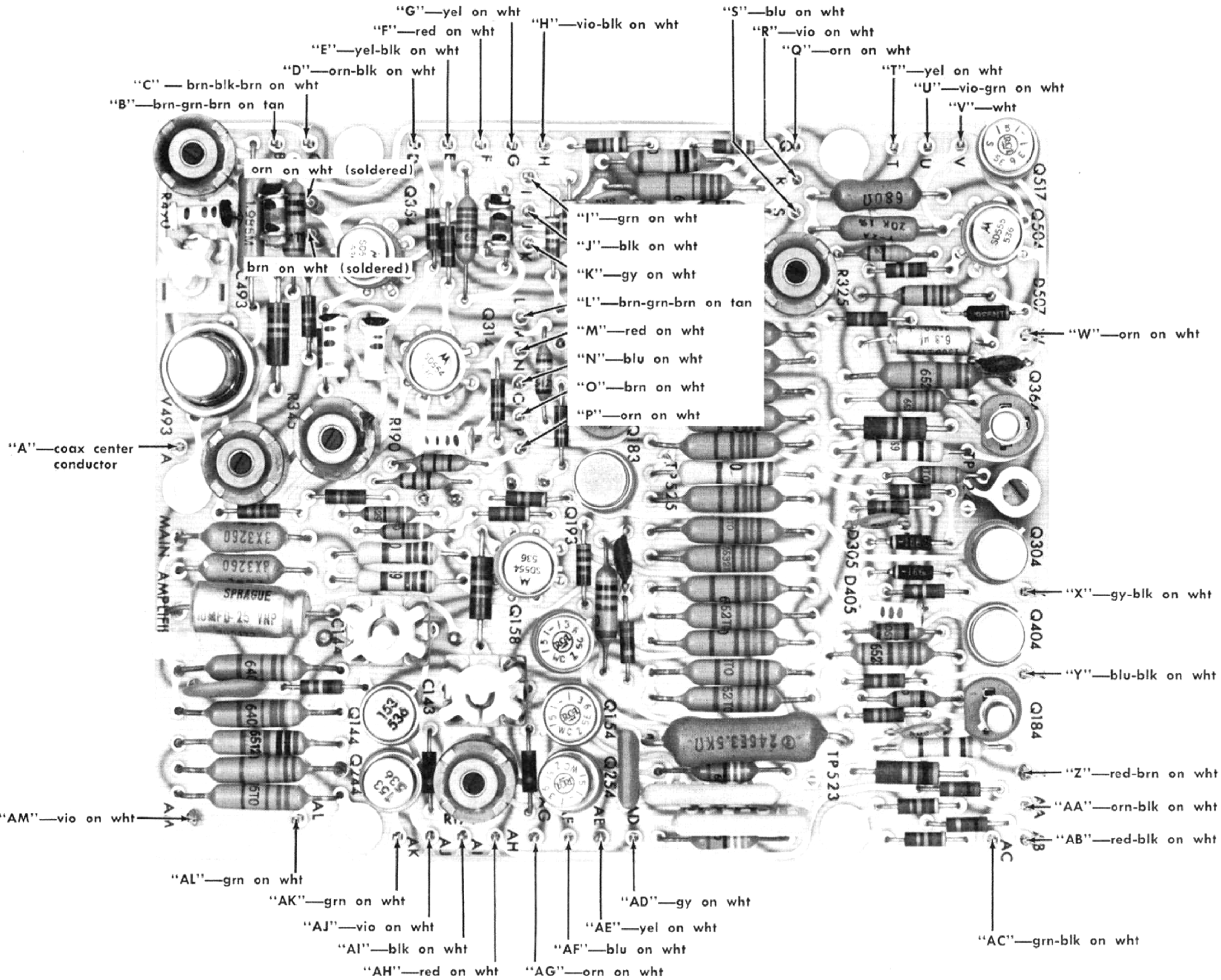


Fig. 4-8. Top view of Main Amplifier etched-wiring board showing the lettered terminals and interconnecting wiring color code.

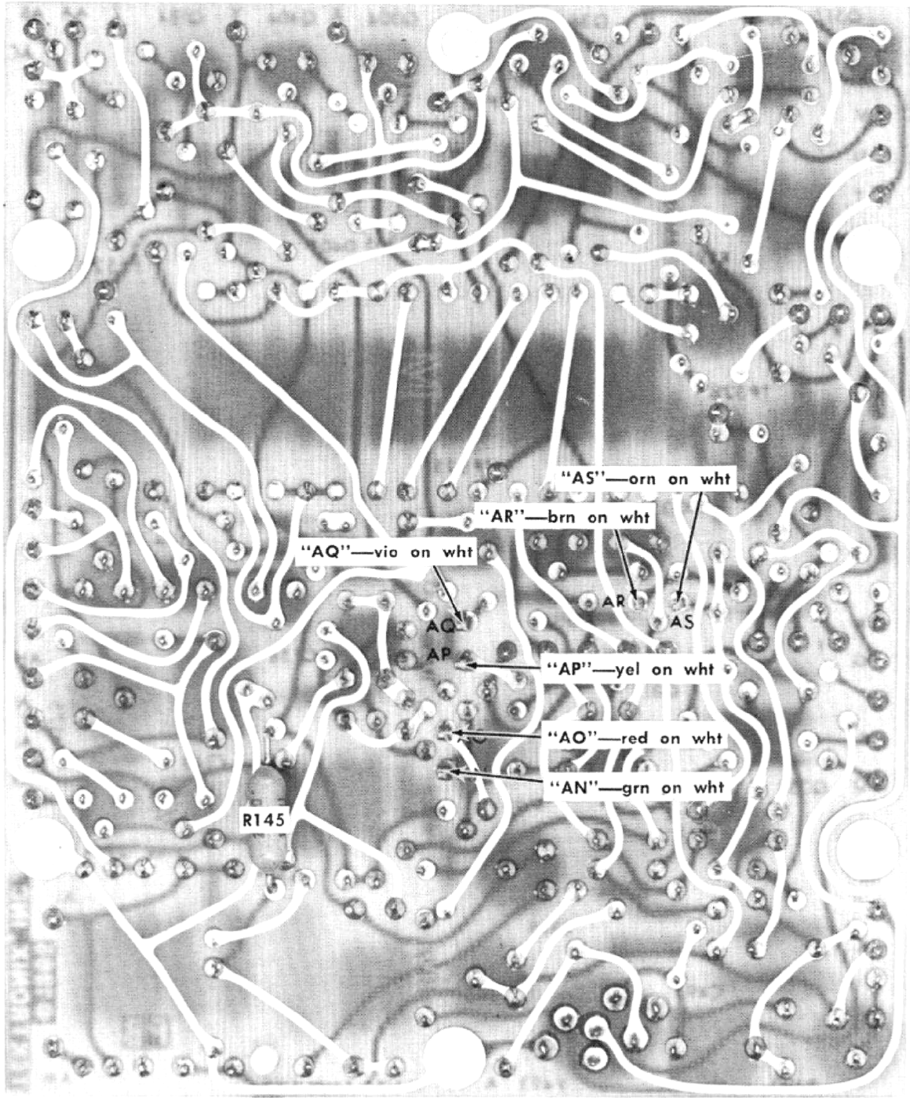
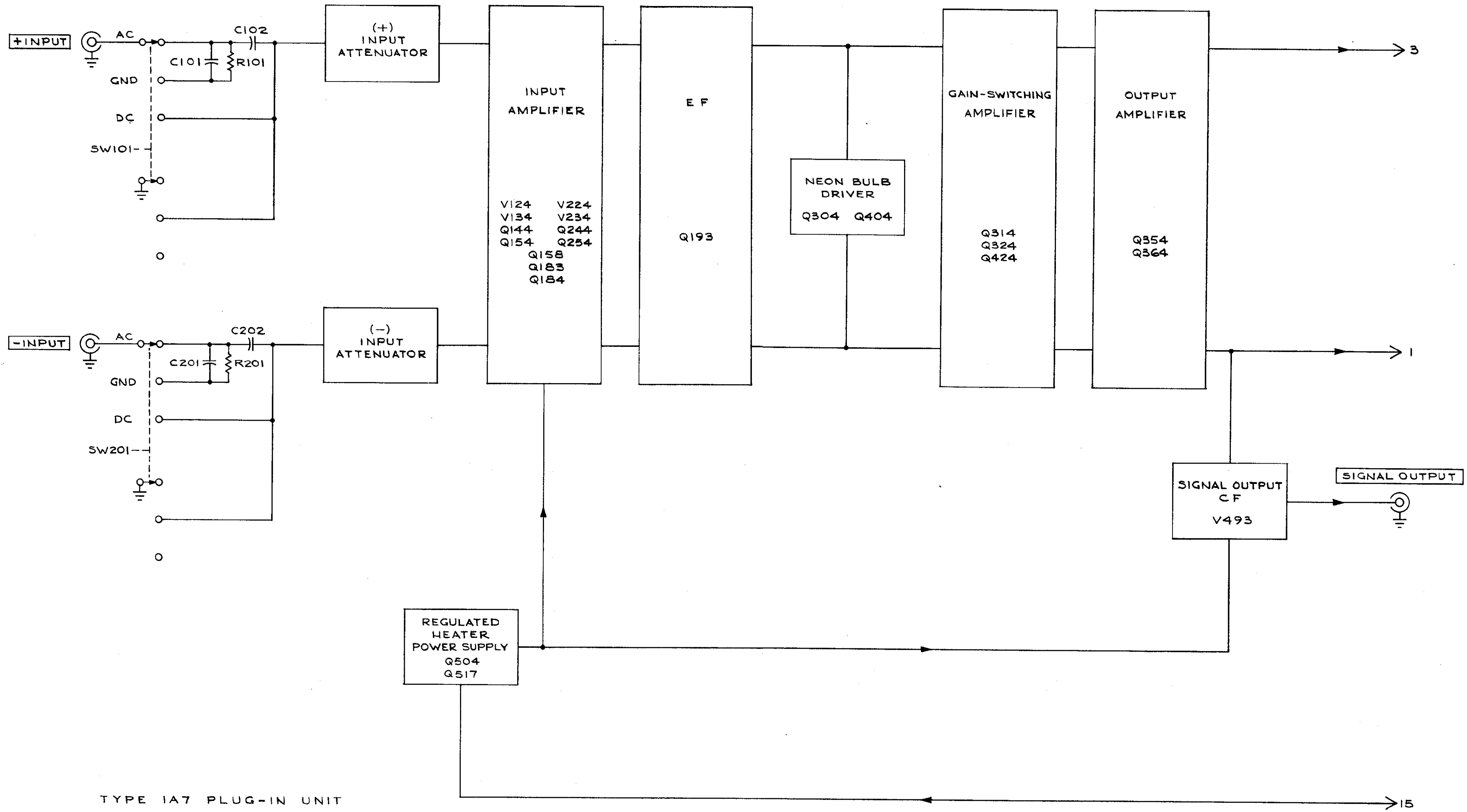


Fig. 4-9. Bottom view of Main Amplifier etched-wiring board.



TYPE 1A7 PLUG-IN UNIT

MRH
865

BLOCK DIAGRAM

IMPORTANT:

Circuit voltages were obtained with a non-loading voltmeter. All readings are in volts. All transistors are forward biased and the voltage drop between emitter and base is about 0.6 V. Voltage and waveform-amplitude measurements are not absolute and may vary from unit to unit. To obtain these measurements, a 30 inch flexible-cable extension (012-0038-00) was used to operate the Type 1A7 out of the oscilloscope plug-in compartment.

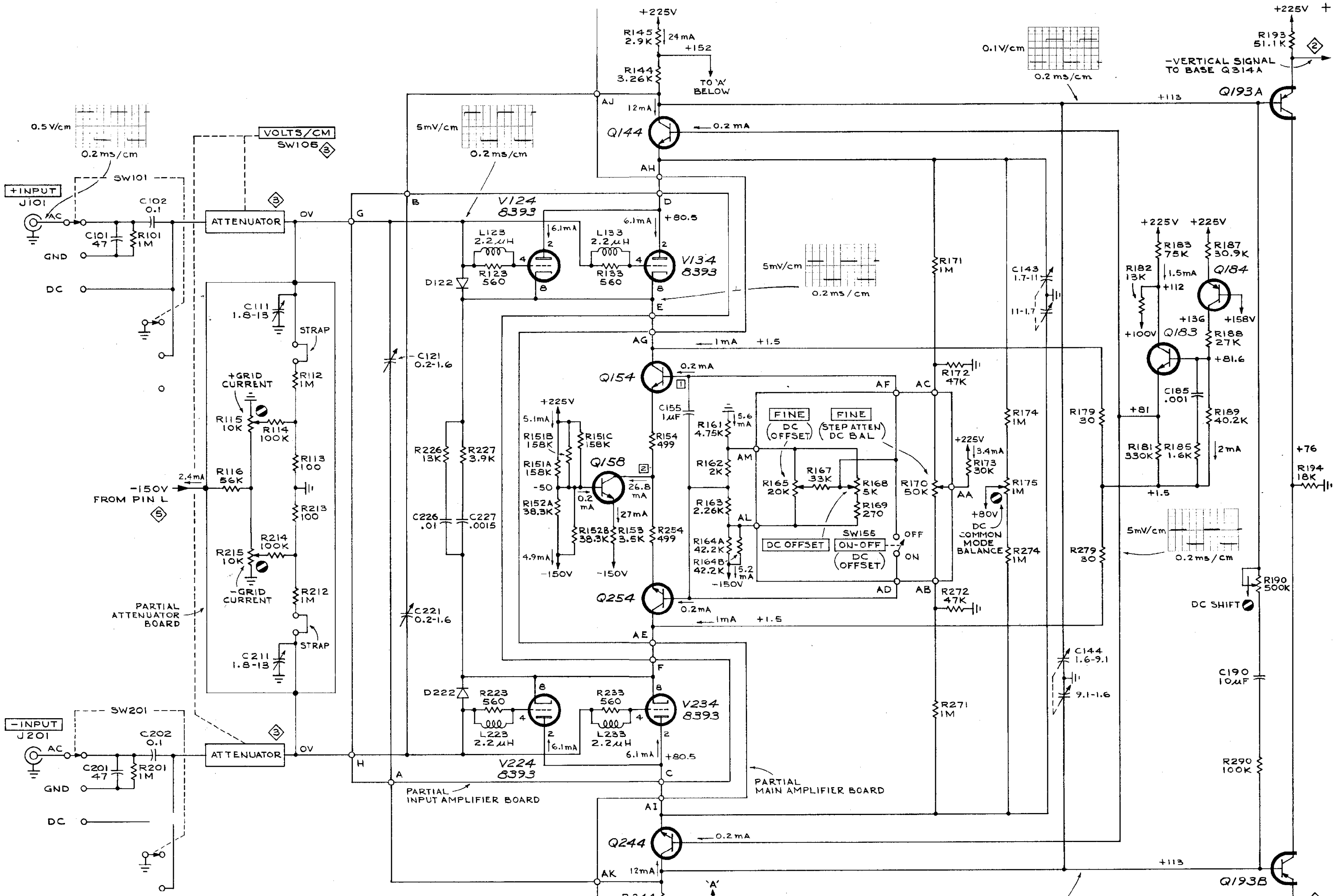
CAUTION

When connecting an extension between the Type 1A7 and a Type 544, 546 or 547 Oscilloscope, pull the oscilloscope plug-in sensing switch outward as soon as possible so the +75 volts is applied to the Type 1A7 regulated heater power supply. In all cases when troubleshooting, do not remove V493 while power is applied.

Actual waveform photographs are shown on the schematic diagrams. To show the waveforms in a time-related sequence, the test oscilloscope used for signal tracing was set for +Ext triggering on a 2-volt reference signal applied to the +INPUT connector of the Type 1A7. Refer to the Maintenance section for full details about signal tracing.

VOLTAGES AND WAVEFORMS were obtained under these conditions:

VOLTS/CM	.5
VARIABLE	CALIBRATED
POSITION	Midrange
HIGH FREQUENCY 3 dB POINT	500 kHz
LOW FREQUENCY 3 dB POINT	DC
AC-GND-DC (+INPUT)	GND (for voltages) AC (for waveforms)
AC-GND-DC (—INPUT)	GND
STEP ATTEN FINE	Midrange
DC OFFSET ON-OFF	OFF (ON, for Tables 1 and 2)



1 VOLTAGE AT BASE Q154			
OFFSET:	CENT	CW	CCW
VOLTAGE	-30.5	-25.5	-35.0

2 VOLTAGE AT COLLECTOR Q158			
OFFSET:	CENT	CW	CCW
VOLTAGE	-37.5	-35.0	-40.0

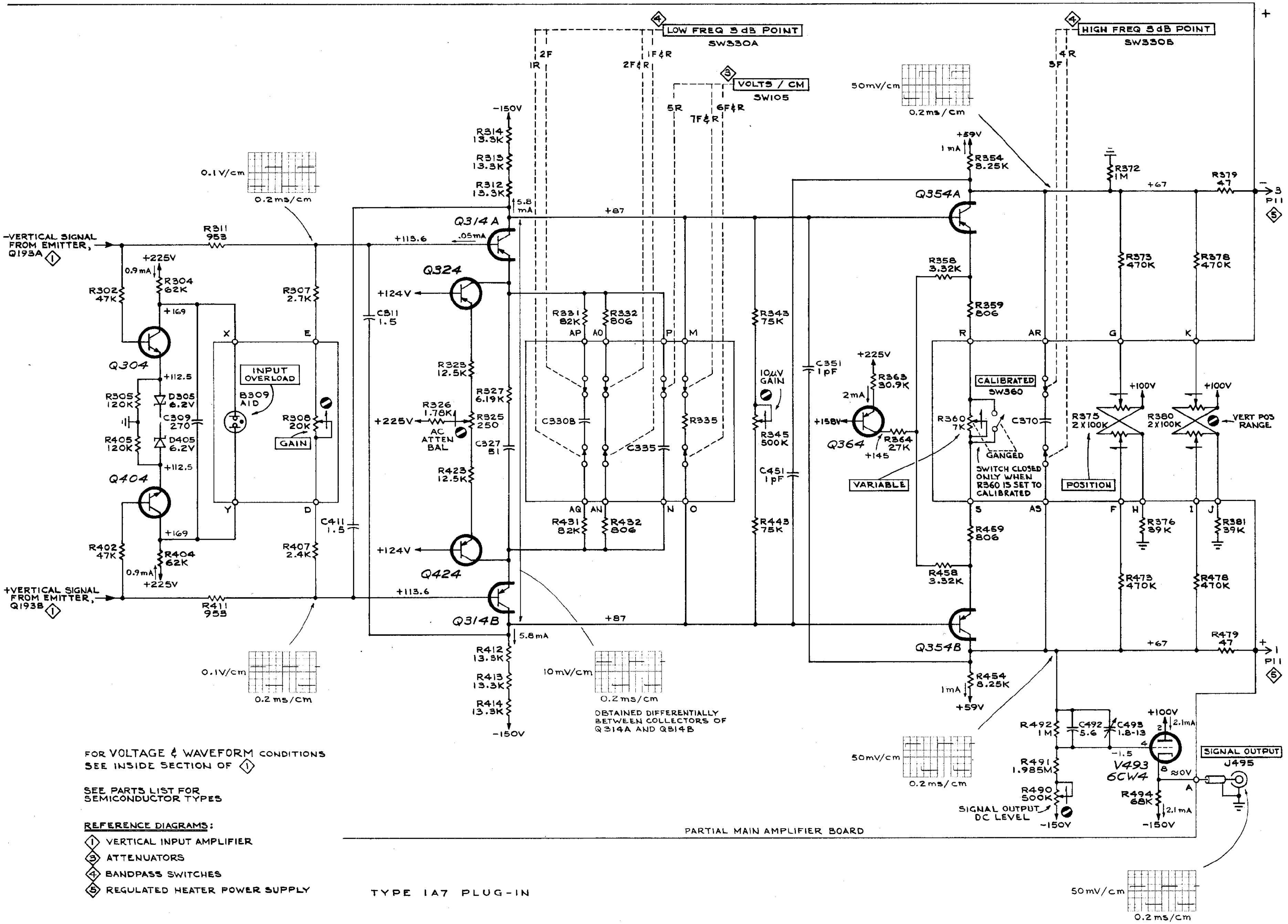
FOR VOLTAGE & WAVEFORM CONDITIONS SEE ADJACENT SECTION OF THIS FOLD-OUT PAGE

SEE PARTS LIST FOR SEMICONDUCTOR TYPES

REFERENCE DIAGRAMS:

- 2 VERTICAL OUTPUT AMPLIFIER
- 3 ATTENUATORS
- 5 REGULATED HEATER POWER SUPPLY

MRH 865



FOR VOLTAGE & WAVEFORM CONDITIONS SEE INSIDE SECTION OF ⟨1⟩

SEE PARTS LIST FOR SEMICONDUCTOR TYPES

REFERENCE DIAGRAMS:

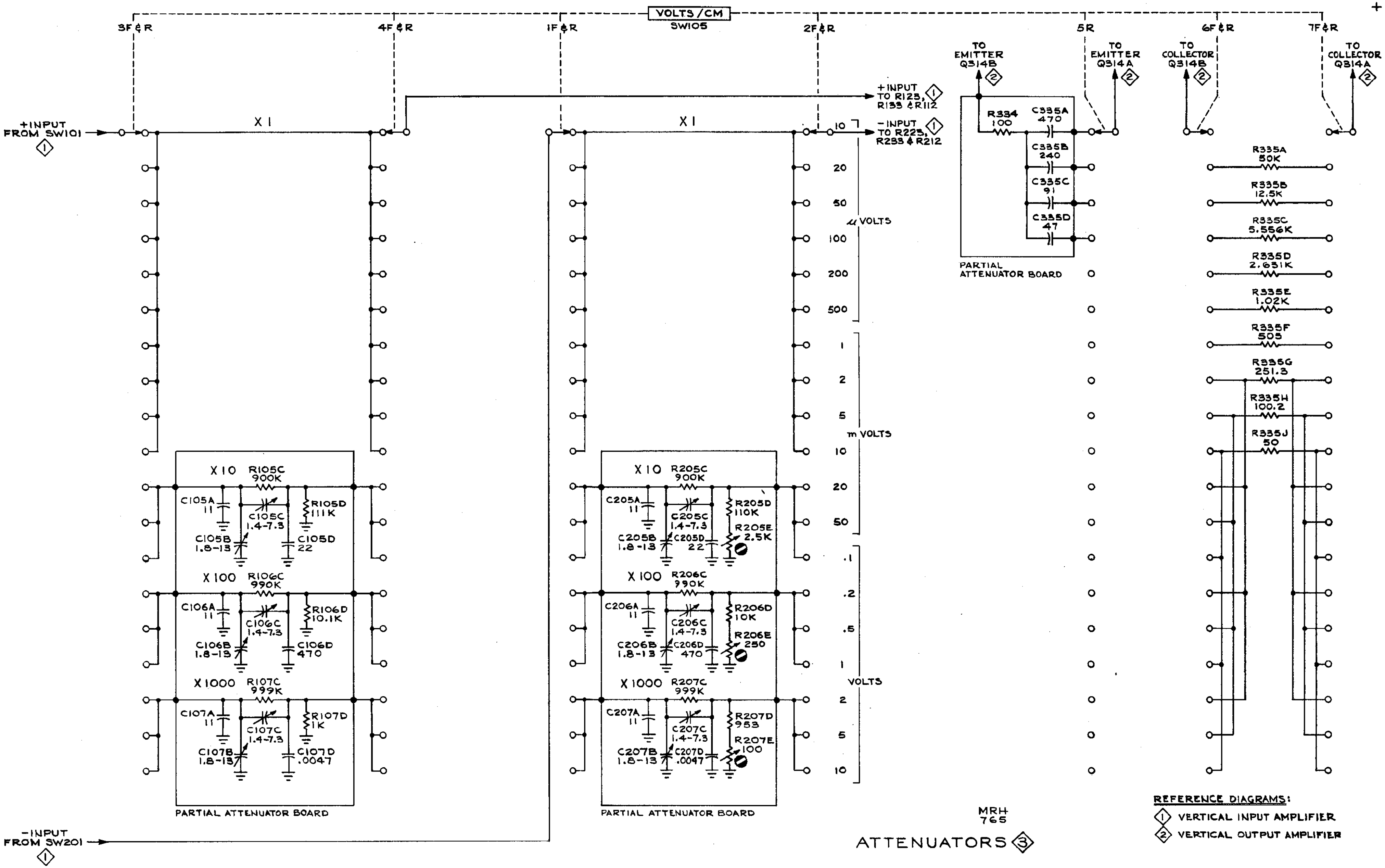
- ⟨1⟩ VERTICAL INPUT AMPLIFIER
- ⟨3⟩ ATTENUATORS
- ⟨4⟩ BANDPASS SWITCHES
- ⟨5⟩ REGULATED HEATER POWER SUPPLY

TYPE 1A7 PLUG-IN

MRH
765

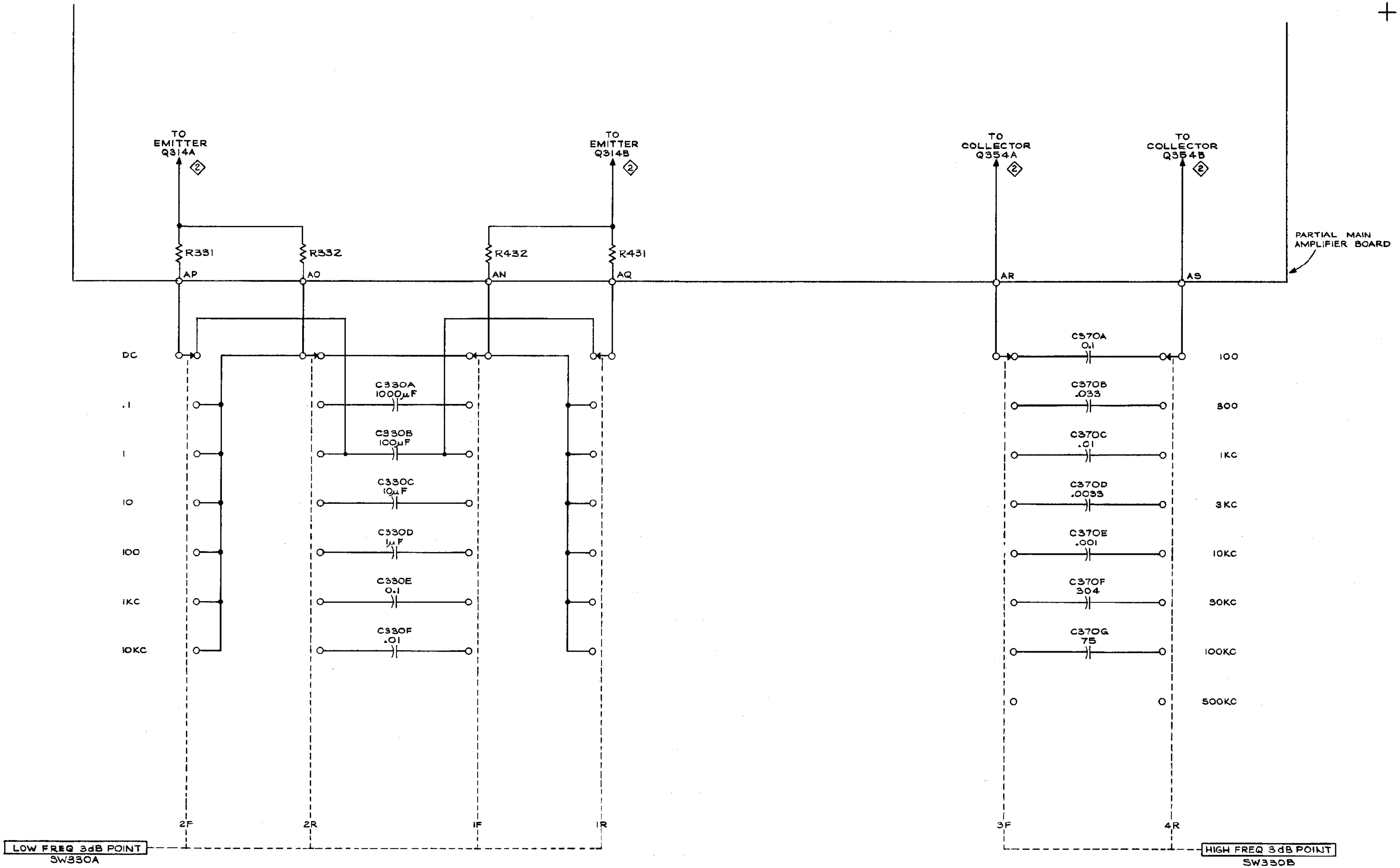
A

VERTICAL OUTPUT AMPLIFIER ⟨2⟩



ATTENUATORS 3

TYPE 1A7 PLUG-IN

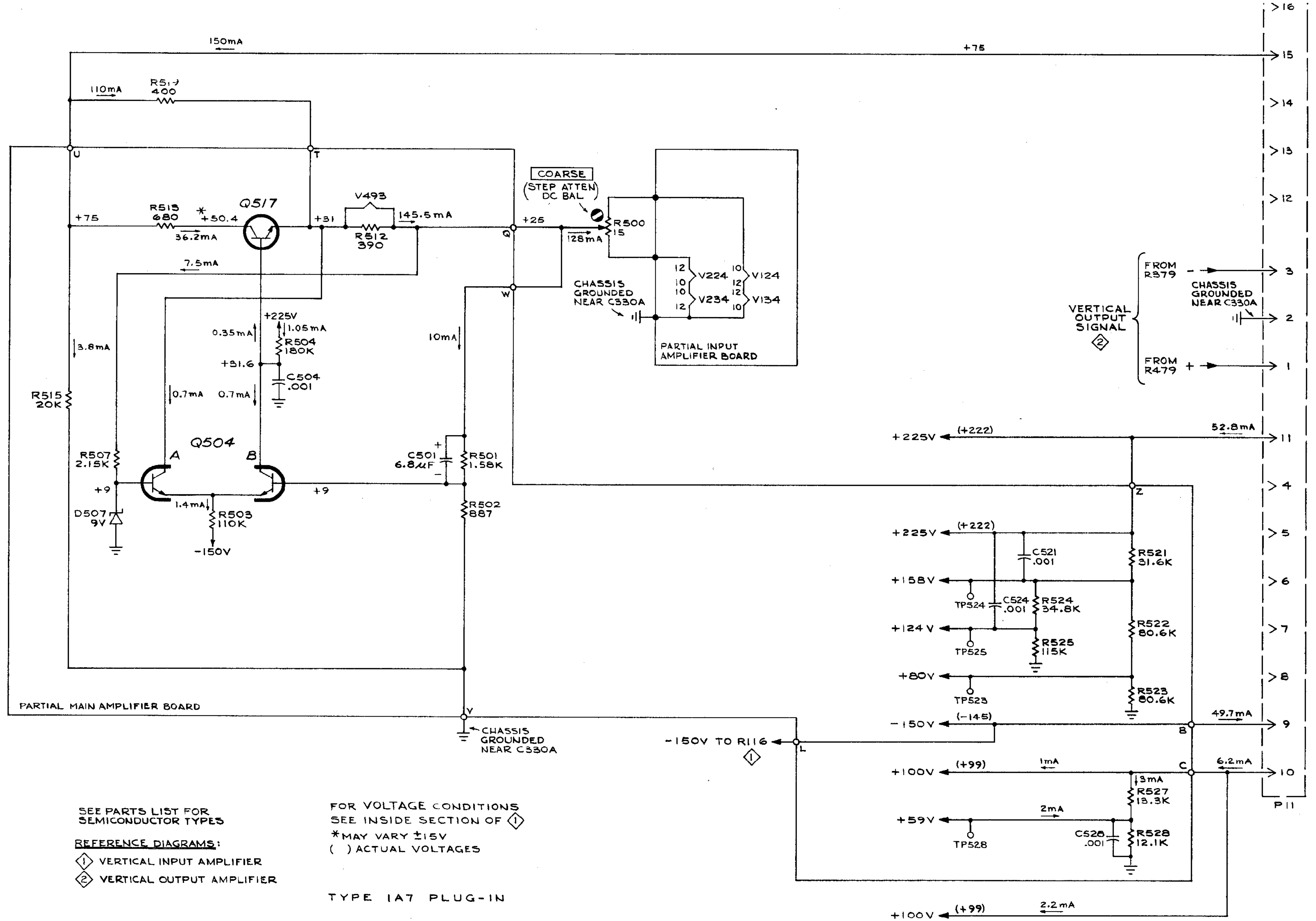


TYPE 1A7 PLUG-IN

REFERENCE DIAGRAM
② VERTICAL OUTPUT AMPLIFIER

GTN
765

BANDPASS SWITCHES ④



SEE PARTS LIST FOR SEMICONDUCTOR TYPES

REFERENCE DIAGRAMS:
1. VERTICAL INPUT AMPLIFIER
2. VERTICAL OUTPUT AMPLIFIER

FOR VOLTAGE CONDITIONS SEE INSIDE SECTION OF 1
*MAY VARY ±15V
( ) ACTUAL VOLTAGES

TYPE 1A7 PLUG-IN

MRH 765

REGULATED HEATER POWER SUPPLY 5